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## INTENSITY OF SOLAR RADIATION AT THE SURFACE OF THE EARTH, AND ITS VARIATIONS WITH LATITUDE, ALTITUDE, SEASON, AND TIME OF DAY<sup>1</sup>

By HERBERT H. KIMBALL, Research Associate

[Blue Hill Observatory, Milton, Mass., December 1934]

A paper under the above title was prepared by I. F. Hand, of the United States Weather Bureau, and myself at the request of the subcommittee on survey, committee on radiation, division of biology and agriculture, National Research Council, for publication in a monograph on "The effect of radiation on living organisms." With the consent of the committee, the paper was given before the American Meteorological Society at the December 1934 meeting, in Pittsburgh, in an abbreviated form, of which the following is a summary:

The principal causes of variation in both the intensity and quality of solar radiation are as follows:

(1) Scattering by the gas molecules of the atmosphere.  
(2) Scattering by the dust and other impurities in the atmosphere. The depletion by both this and the preceding cause is at a maximum in the ultra-violet, and diminishes toward the infra-red or long-wave end of the spectrum.

(3) Absorption by atmospheric gases, principally by water vapor in well-marked bands in the infra-red, and by ozone in the ultra-violet.

The following causes affect principally the intensity of solar radiation as received by the earth.

(4) The distance of the earth from the sun, which is at its maximum early in July, minimum early in January, and mean in early April and early October. As a result, with similar atmospheric conditions, and the same solar zenith distance, intensities early in January should exceed those in early July by 7 percent.

(5) Variations in the value of the solar constant, which variations are insignificant in comparison with (1) to (4), enumerated above.

If we multiply the atmospheric transmission coefficients given by the curved lines of Figure 1 by 1.94, the value of the solar constant of radiation, we obtain the corresponding solar radiation intensities. Thus, for Washington, D. C., in June, with the sun 60° from the zenith, air mass 2, the average transmission is 0.474, and the radiation intensity is 0.92 gr. cal./min./cm<sup>2</sup>.

Figure 1 shows the highest radiation intensity ever measured to be 1.84 gr. cal./min./cm<sup>2</sup>; it was obtained by means of a pyrheliometer attached to a balloon which carried the instrument to a height of 22,000 meters. The second highest intensity was also obtained by means of a pyr-

heliometer attached to a balloon and carried to a height of 7,500 meters, where an intensity of 1.80 gr. cal./min./cm<sup>2</sup> was obtained. A group of stations on mountains ranging in height from 3,500 to 4,500 meters give intensities of about 1.75 gr. cal./min./cm<sup>2</sup>. These intensities have all been extrapolated to what they would have been with the sun in the zenith, and with the earth at its mean solar distance.

Coming down to lower level stations, we obtain for Lincoln, Nebr., an intensity of 1.53 in February, and 1.32 in August; while for Washington, D. C., altitude 127 meters, the intensity for February is 1.45, and for June, 1.24; all in gram calories per minute per square centimeter of surface normal to the incident radiation.

The depression of the summer intensities at Lincoln and Washington as compared with the winter intensities, when reduced to mean solar distance and to intensity for the sun in the zenith, show the seasonal variation in solar radiation intensities at these two stations. This depression is shown for other stations through the comparison of mean noon values actually observed, as follows:

Santa Fe, N. Mex., August, 1.43; December, 1.52; Washington, D. C., 1.19, for both August and December, the lowest averages for noon for any months; Blue Hill, Mass., 1.25, also for August and December, with no lower average in any other month; Madison, Wis., 1.28 in August, with 1.24 in October, and 1.29 in September and December. Madison, however is the farthest north of the pyrheliometric stations in the United States, and the latitude effect is more noticeable here in the winter months than at stations in lower latitudes.

Within the Arctic Circle, in midwinter, the solar radiation is, of course, zero. With the return of spring, however, high intensities prevail. Thus, at Mount Evans, on the Greenland ice cap, latitude 66°51' N, altitude 363 meters, in April, with solar zenith distance 60° and 70.7°, respectively, the measured mean solar radiation intensities were 1.45 and 1.28 gr. cal./min./cm<sup>2</sup>, which are substantially the intensities measured at Davos, Switz., lat. 46°48' N, altitude 1,561 meters; again, at Treurenberg, Spitsbergen, latitude 79°55' N, altitude 3 meters, in May, June, and July, with the sun 70.7° from the zenith, the average measured intensity was 1.33 gr. cal./min./cm<sup>2</sup>, the same as the intensities measured on Mount Wilson, Calif., about a mile above sea level, with the sun at this same distance from the zenith.

<sup>1</sup> Substantial assistance from the geophysical research fund of the Blue Hill Observatory in the preparation of this summary is gratefully acknowledged.

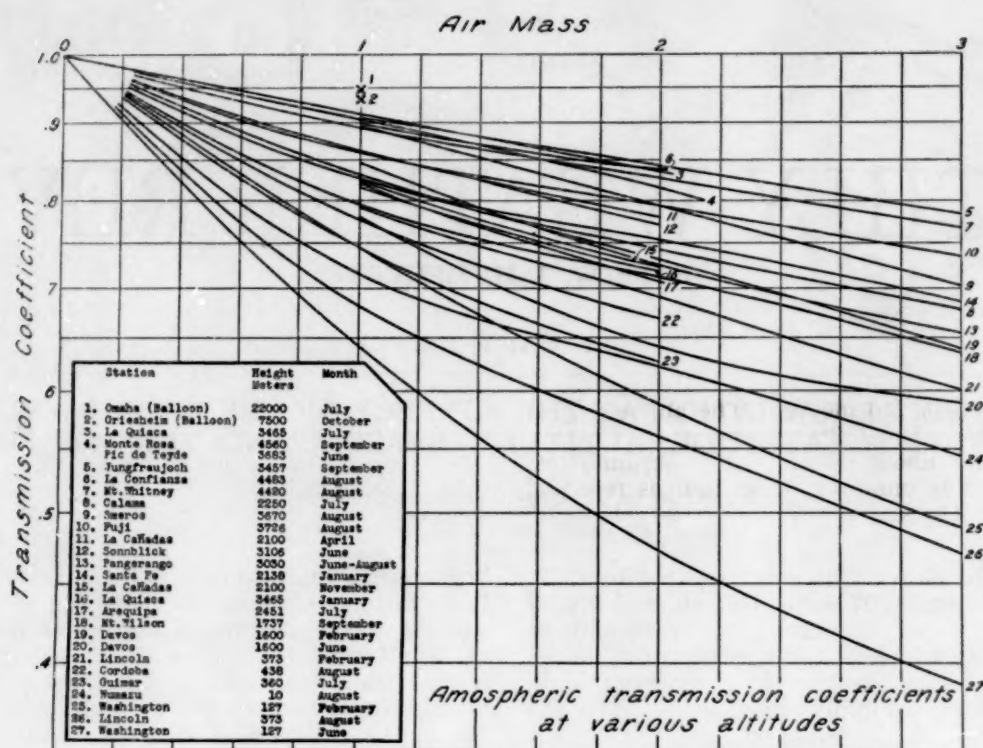


FIGURE 1.—Atmospheric transmission coefficient different altitudes.

The following are representative low-level stations within the tropics, and their radiation values:

| Stations           | Latitude | Longitude | Altitude, meters | Solar zenith distance | Radiation intensity | Month     |
|--------------------|----------|-----------|------------------|-----------------------|---------------------|-----------|
| Flint Island.....  | 10 05 S  | 152 10 W  | —                | 60                    | 1.29                | Dec.      |
| Apia, Samoa.....   | 13 48 S  | 171 46 W  | 2                | 60                    | 1.10                | Nov.-Feb. |
| Do.....            |          |           |                  | 60                    | 0.98                | Mar.-Oct. |
| Bangkok, Siam..... | 13 44 N  | 100 30 E  | 10               | 5                     | 1.22                | May.      |
| Batavia, Java..... | 6 11 S   | 106 50 E  | 8                | 60                    | 1.13                | Jan.-Feb. |
| Do.....            |          |           |                  | 60                    | 0.85                | Aug.-Oct. |

The following table of intensity readings obtained at Washington, D. C., on the afternoon of November 9, 1909, with an Ångström pyrheliometer, shows the variations in intensity as the sun approaches the horizon.

|                            |       |       |       |       |       |       |       |       |       |       |       |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Solar zenith distance..... | 60.0  | 75.7  | 80.7  | 83.2  | 84.7  | 85.8  | 86.9  | 87.6  | 88.2  | 88.7  | 89.2  |
| Air mass.....              | 2.0   | 4.0   | 6.0   | 8.00  | 10.0  | 12.0  | 15.0  | 18.0  | 21.0  | 25.0  | 29.0  |
| Intensity; gr. cal.....    | 1.230 | 0.999 | 0.804 | 0.653 | 0.531 | 0.454 | 0.365 | 0.292 | 0.236 | 0.176 | 0.131 |

Unit air mass is defined as the length of the vertical path through the atmosphere. The path is twice as long ( $m=2$ )  $60^\circ$  from the zenith, and 25 times as long  $88.7^\circ$  from the zenith, or  $1.3^\circ$  above the horizon. The solar intensity for air mass 2 was only slightly above the average for November. Therefore, we may say that the intensity for zenith distance of the sun  $89.2^\circ$ , or altitude above the horizon  $0.8^\circ$ , approximates closely to the intensity just before the lower limb of the sun touches the horizon.

The vertical component of the total solar radiation (direct + diffuse) received at the surface of the earth.—About half the radiation lost from the incoming rays through scattering, as already described, is finally received at the surface of the earth as diffuse radiation. This, added to

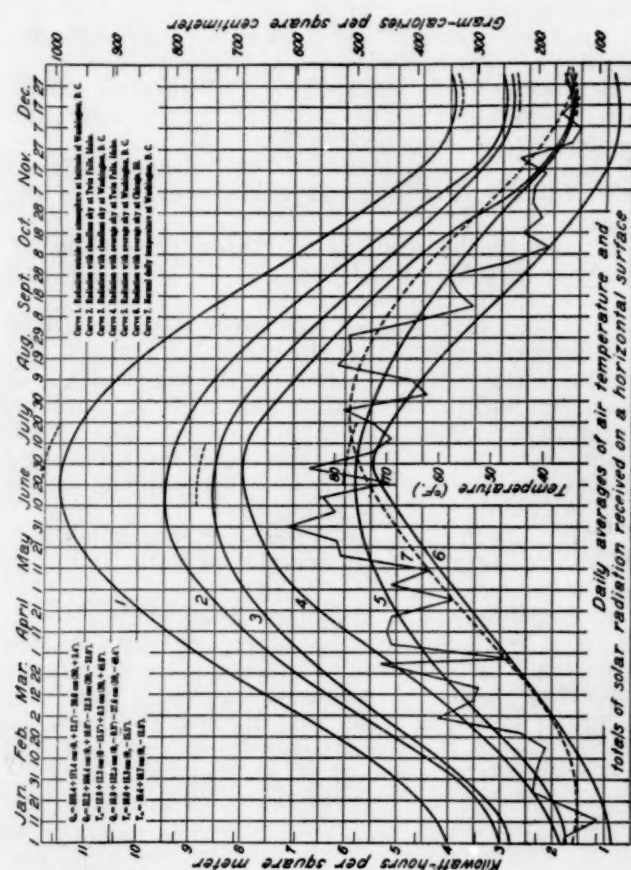


FIGURE 2.—Annual curves of daily totals of radiation.

the vertical component of the direct solar rays, makes up the total radiation received at the surface of the earth. Figure 2 gives annual curves of daily totals of radiation.

Curve 1 is for just outside the atmosphere at the latitude of Washington, and is simply the vertical component of the direct solar radiation, or the vertical component of the solar constant corrected for the distance of the earth from the sun. Curves 2 and 3 give daily totals of the average radiation, including the diffuse, received on cloudless days at Twin Falls, Idaho, latitude  $42^{\circ}29'$  N, altitude 1,310 meters, and at Washington, D. C., latitude  $38^{\circ}56'$  N, altitude 30 meters; while curves 4 and 5 give these radiation data for the average of all days, at the respective stations. On the normal values of curve 5 are superposed the weekly averages for Washington for the year 1925, to show the rapid fluctuations in radiation receipt from week to week.

In curve 6 are given weekly averages for Chicago, Ill., latitude  $41^{\circ}37'$ , altitude 210 meters. The annual totals received at the three smoky cities, Chicago, Pittsburgh, and New York, are about 100,000 gr. cal./min./cm<sup>2</sup>, which is approximately one-fourth less than is received at Washington, D. C., and Blue Hill, Mass., both of which have relatively clear atmospheres (the latter is also on nearly the same latitude as the three cities first named), and one-third less than is received at stations like Riverside and Fresno, Calif., and Twin Falls, Idaho.

For the maximum average daily total radiation, we have from figure 2, curves 4 and 5, for Twin Falls and Washington, respectively, 689 and 500 gr. cal./cm<sup>2</sup>. Outside the United States, for Johannesburg, South Africa, 606 gr. cal. in November; Habana, Cuba, 658 gr. cal., in July; Fairbanks, Alaska, just outside the Arctic Circle, 583 gr. cal. in June; at Abisko, Sweden, just within the Arctic Circle, 468 in June; at Green Harbor, latitude  $78^{\circ}$  N., 546 in June; and at Sveanor, Spitzbergen, latitude  $80^{\circ}$  N., for the 22 days from June 10 to July 1, inclusive, the average daily radiation received was 580 gr. cal.

For the mid-day hourly amount in June we have the following, in gr. cal.: For Miami, Fla., 66.8; Washington, D. C., 66.8; Lincoln, Nebr., 64.4; Twin Falls, Idaho, 77.4; Fresno, Calif., 83.6; Fairbanks, Alaska, 59.6. It thus appears that while in the Arctic regions the intensity of solar radiation at normal incidence, and the total daily amounts in mid-summer, compare favorably with like data for stations at lower latitudes, and especially with tropical stations, nevertheless the mid-day hourly amounts received on a horizontal surface are much less, on account of the comparatively low altitude of the sun at this time.

**Variations in the quality of solar radiation.**—At Washington, D. C., and at the Blue Hill Observatory, Milton, Mass., the intensity of the radiation has been measured by means of glass color screens that cut out all radiation of wave lengths below a certain point in the spectrum that is quite accurately known, but which may be shifted slightly by changes in the temperature of the screens (which are necessarily exposed to the sun outside the observatory). The effect of this temperature change is a subject that is scheduled for investigation.

An abundance of screened solar radiation measurements are available from both European and American observatories, but time has permitted the examination of only a small fragment of the data in quite a preliminary manner.

The sections of the spectrum measured are as follows: (Consult, fig. 3.) (1), the total spectrum; (2), all above  $0.636\mu$ , or the red and infra-red, here for brevity designated "red"; (3), all above  $0.526\mu$ . In addition to (2), the red band, (1) minus (3), gives a measure of the intensity in that part of the spectrum below  $0.526\mu$ , or in the blue-violet, for brevity here designated "blue"; while

(3) minus (2), or between  $0.526\mu$  and  $0.636\mu$ , which includes most of the so-called visible spectrum, is here designated "visible."

The measurements from three typical stations, including Zugspitze, Germany, lat.  $47^{\circ}25'$  N., long.  $10^{\circ}59'$  E., altitude 2,962 meters, may be summarized as follows:

## ZUGSPITZE, GERMANY

| Season of year    | Air mass | Percentage of total in each |      |         |
|-------------------|----------|-----------------------------|------|---------|
|                   |          | Red                         | Blue | Visible |
| Winter.....       | 3.82     | 68.6                        | 18.8 | 12.8    |
| Year.....         | 2.90     | 67.7                        | 19.3 | 12.9    |
| Spring.....       | 2.37     | 65.7                        | 21.1 | 13.1    |
| March-August..... | 2.00     | 63.1                        | 22.9 | 14.1    |
| April-August..... | 1.53     | 62.2                        | 24.1 | 13.6    |
| June-August.....  | 1.14     | 61.1                        | 25.0 | 13.9    |

## BLUE HILL, MASS.

|                        |      |      |      |      |
|------------------------|------|------|------|------|
| Winter.....            | 3.47 | 72.3 | 13.4 | 14.1 |
| Summer.....            | 3.26 | 67.1 | 16.0 | 16.9 |
| January-October.....   | 2.30 | 68.0 | 16.3 | 15.7 |
| November-December..... | 2.51 | 69.8 | 14.8 | 15.4 |
| June.....              | 1.25 | 62.8 | 20.6 | 16.6 |

## WASHINGTON, D. C.

|                       |      |      |      |      |
|-----------------------|------|------|------|------|
| January-December..... | 3.61 | 70.8 | 14.1 | 14.9 |
| Do.....               | 2.35 | 68.8 | 16.1 | 15.0 |
| February-April.....   | 1.56 | 65.7 | 19.9 | 14.3 |

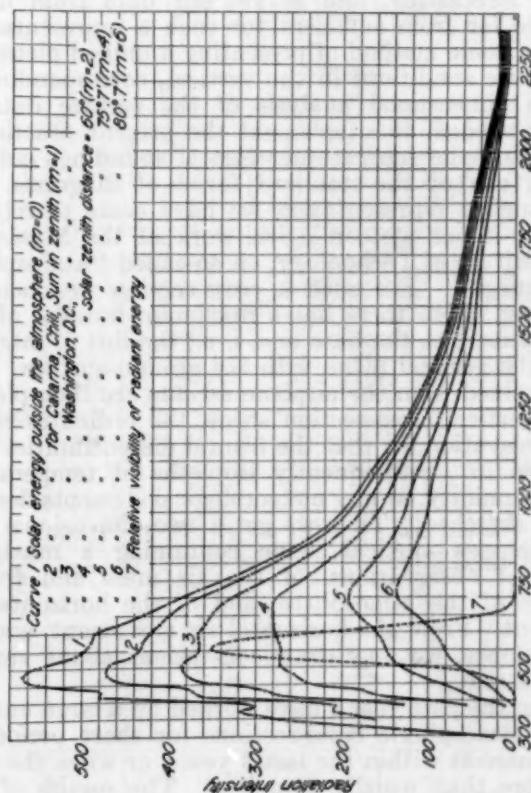


FIGURE 3.—Normal solar radiation energy curves.

The following relations are to be noted:

(1) An increase in the percentage of the blue content of the solar spectrum occurs with decrease in air mass, as we should expect, since the depletion by scattering in that part of the spectrum is much greater than in the longer wave-length sections.

(2) A decrease in the percentage of the red content of the solar spectrum occurs with decrease in air mass, which

is probably a seasonal effect, since depletion in the long-wave end of the spectrum is largely due to absorption by water vapor, and water vapor is much more abundant in the atmosphere during the warm than during the cold season of the year.

(3) Variations in the visible part of the spectrum, while small, indicate about the same increase in the percentage content of visible radiation in the solar spectrum with decrease in air mass as is indicated by table 3, p. 479, MONTHLY WEATHER REVIEW for October, 1924 "Illumination equivalents of a gram-calory/min./cm<sup>2</sup> of radiation, with the sun at different zenith distances." The increase there shown from zenith distance 75.7 ( $m=4.0$ ) to zenith

distance 25° ( $m=1.1$ ) is 9 percent, which is the same as is shown for Zugspitze, above.

While existing solar radiation measurements in the Tropics are inadequate to give a complete picture of its characteristics, the data here presented do not substantiate the claims frequently made as to its excessive intensity as compared with that in temperate zones. The annual total received on a horizontal surface at Habana, Cuba, for example, is about the same as that received at Lincoln, Nebr., and considerably less than that received at stations in the States of California and Idaho; while the maximum hourly amount received at Miami, Fla., is considerably less than that received at most stations in central latitudes of the United States.

## ROUTINE DAILY PREPARATION AND USE OF ATMOSPHERIC CROSS SECTIONS

By HURD C. WILLETT

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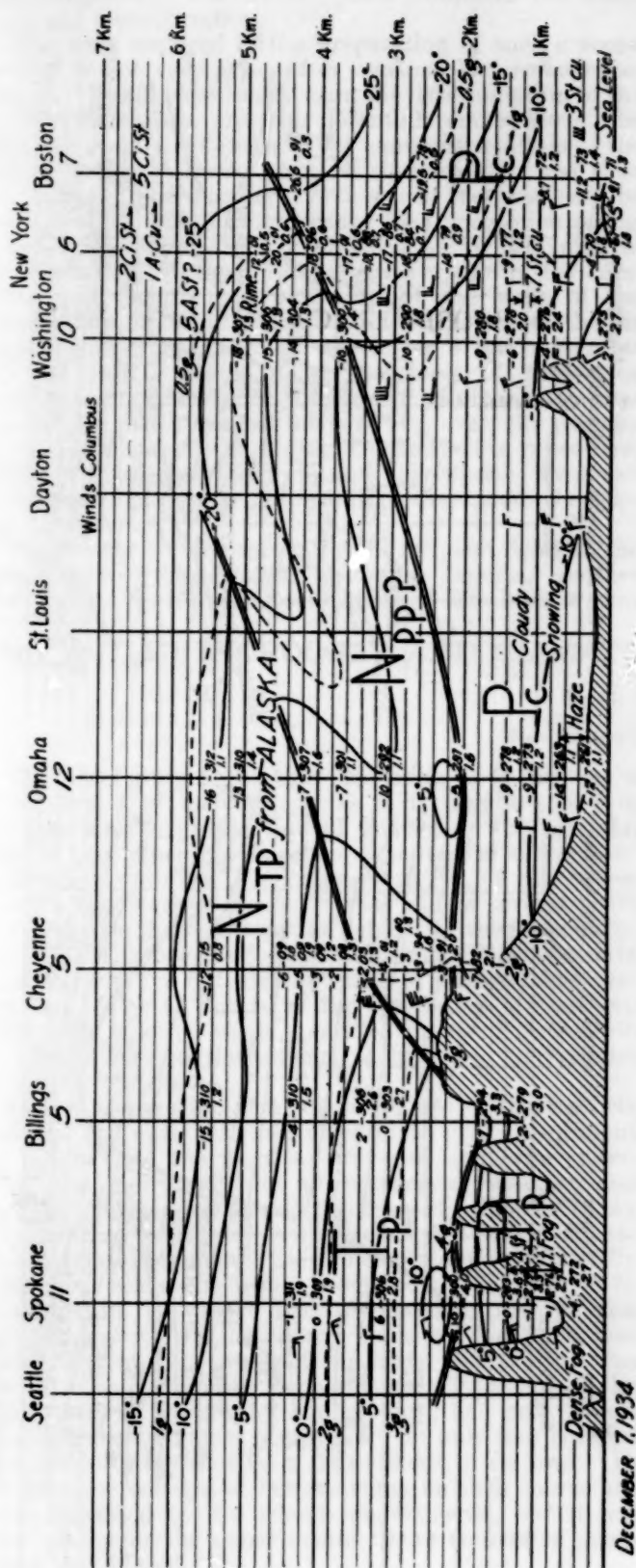
The greatly increased number of daily meteorological soundings through the lower troposphere by airplane which are now at the disposal of the American weather forecaster makes necessary the development of a system for the representation of these valuable data, in the most useful and comprehensive form which limited time will allow. Any complete three-dimensional representation of the fields of the meteorological elements is likely to remain too complicated a procedure for use in daily weather forecasting, and as yet our data from upper levels are far from sufficient for such a representation. However, some method of presenting a unified picture of atmospheric conditions in the vertical, corresponding to our two dimensional analysis of the surface data, is urgently needed, to supplement the present practice of representing the separate aerological soundings individually on one of the standard forms of diagrams. To obtain such a representation we have come to rely increasingly in our meteorological work at the Massachusetts Institute of Technology, on so-called "atmospheric cross sections." For such a cross section we choose a line, along which there lies a maximum number of airplane stations, as the base line, i. e., the line of intersection of the vertical plane with the ground surface. The data obtained from the airplane ascents are then plotted on the vertical cross-section sheet, the ordinates representing elevation, so that the frontal discontinuities may be drawn in. Subsequently isopleths of temperature, specific humidity, or any meteorological elements desired, may be sketched. Thus we get a two-dimensional picture, along a vertical plane containing a maximum number of observations, of the air mass and frontal structure of the atmosphere, and of the horizontal air movement. From the horizontal air movement, and the frontal slopes, we may draw conclusions about vertical velocities also.

During the past year I have worked up a large number of such atmospheric cross sections for short periods of special interest within the last 3 years, or when the data were more than usually complete. The results of this work proved to be of such interest and so illuminating that I decided at the end of last summer to try to work out some routine practice by which at least a part of the present extensive network of stations making daily airplane soundings might be utilized in the regular daily preparation of certain standard cross sections. For this purpose 3 groups of stations were chosen, 2 of these groups constituting rather straight north-south sections, and 1 long east-west section along a broken line. In the more

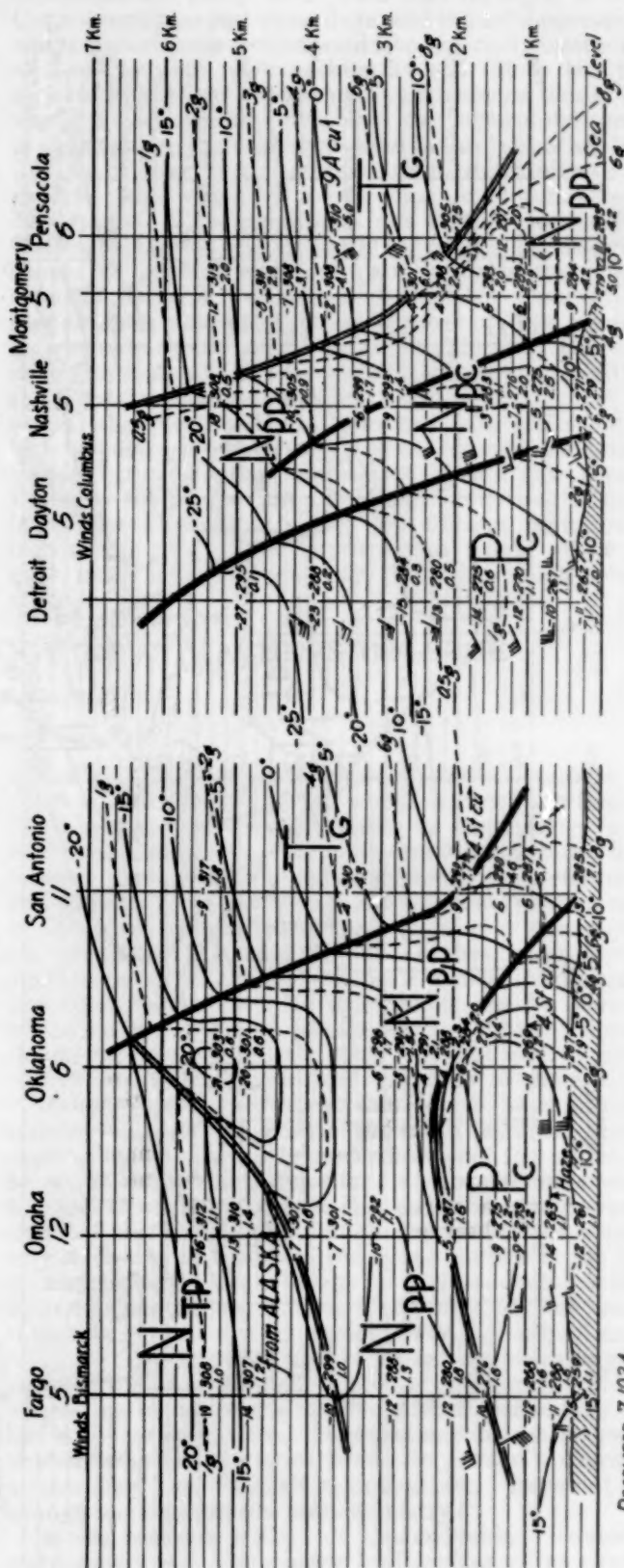
easterly north-south section are Detroit, Dayton, Nashville, Montgomery, and Pensacola; in the more westerly one, Fargo, Omaha, Oklahoma, and San Antonio. In the long broken east-west section we have Boston, New York, Washington, Dayton, St. Louis, Omaha, Cheyenne, Billings, Spokane, and Seattle. On our cross-section sheets the ordinates give elevations (scale 1 inch to 1 kilometer), and the abscissae are horizontal distances (same scale as the M. I. T. weather maps). The base line represents roughly the topographical contour, on the given scale of elevation, of the ground surface along each section. Vertical lines at the point of each station serve to facilitate the plotting of the data in the vertical.

Lack of time usually prevents the daily plotting of all three cross sections. Usually it is the aim to complete the east-west section every day, and the north-south sections only in cases of particular interest. There are occasions when, owing to more complete data or to the particular meteorological situation, the completion of one or both of the north-south sections may be preferred to that of the east-west section. The plotting procedure is quite simple. The desired stations are selected from the morning reports, and for each reported level the potential temperature and specific humidity are obtained graphically. Then at the respective elevations (points on the vertical line representing each station) the potential temperature and specific humidity are entered at the right, the actual temperature at the left. Where we have pilot-balloon observations, the wind direction and velocity (Beaufort) are also represented by barbed arrows, the direction parallel to the base line representing the direction of the baseline itself. Thus on a west-east section a wind arrow flying to the right and parallel to the base represents a west wind, on a north-south section, a north wind.

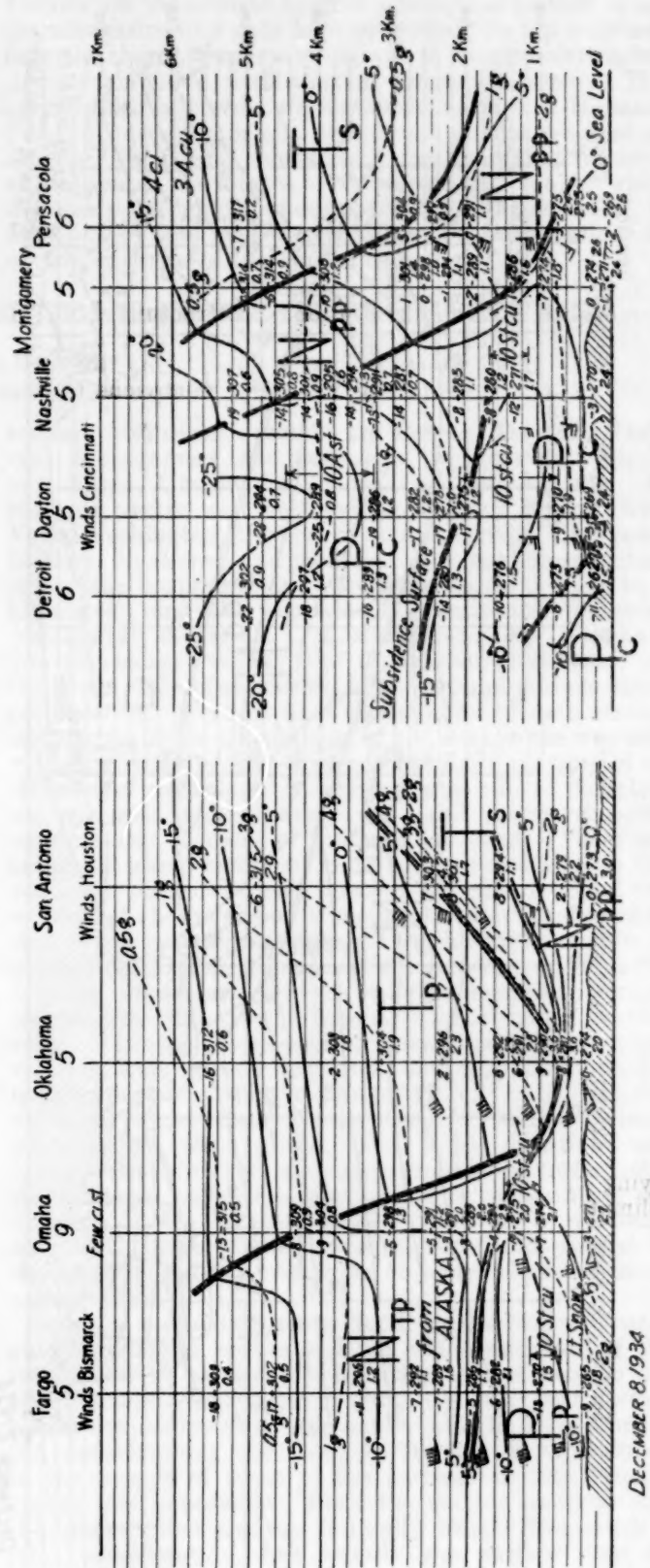
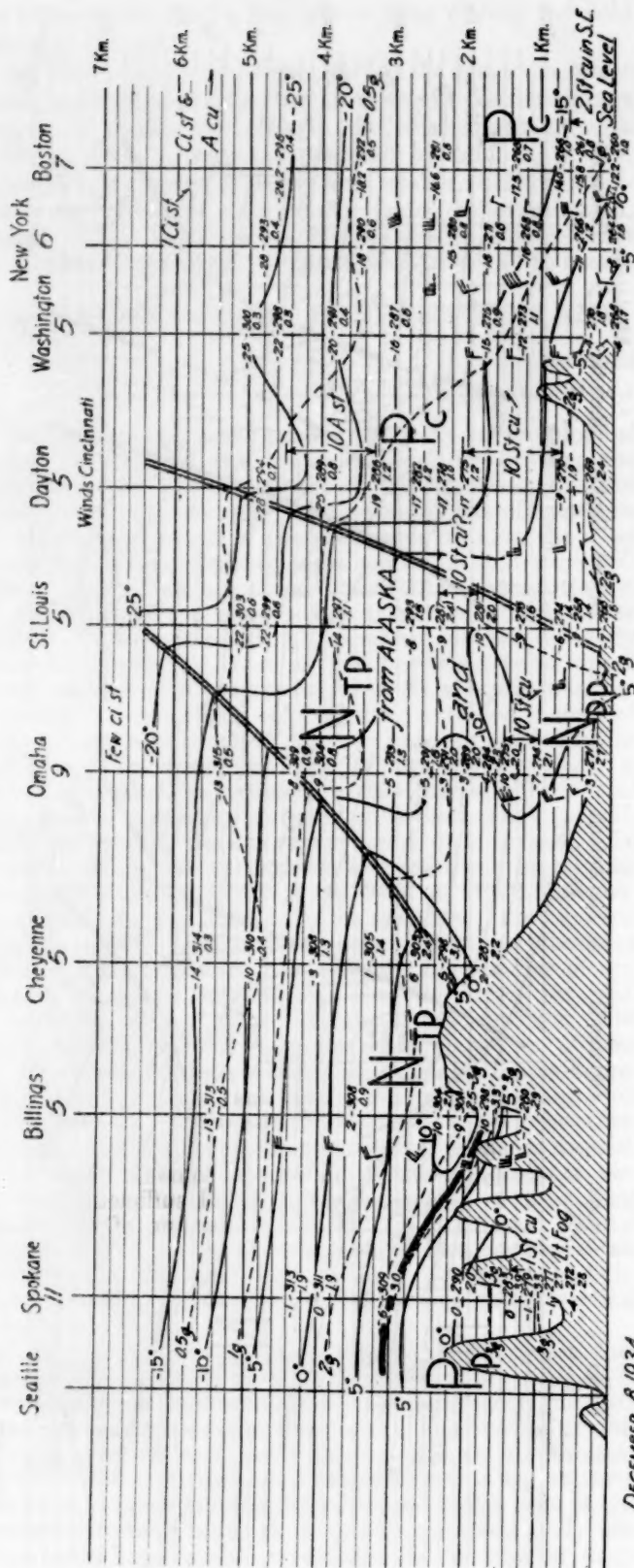
As soon as the data are entered, we are ready to carry out the analysis, or the location and designation of the fronts and air masses. This is not always easy to do, and requires considerable experience. It is best carried out in conjunction with the analysis of the surface map, but unfortunately the delay so frequently experienced in the receipt of some of the aerological data usually makes this impossible. Both the surface analysis and the cross-section analysis mutually benefit from such a joint consideration, but usually the surface analysis cannot be delayed until all the aerological observations are in, and of course the cross section analysis should be attempted only with the greatest possible amount of material plotted on the cross section. When the loca-



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tion of the fronts and air masses is completed, isopleths of specific humidity and of either temperature or potential temperature are drawn. This completes the cross-sectional representation.

The time required in the preparation of such a cross-section is not very great after one has had some experience. By an experienced man the determination of the specific humidities and the potential temperatures, the plotting of all the data, and the complete analysis of the major west-east section can be completed in less than 1½ hours. The smaller north-south sections can be completed in about ¼ hour each. The completion of the three cross sections, when the airplane reports are received from all stations, furnishes one with a rather complete and comprehensive picture of the state of the atmosphere, or the distribution and structure of the air masses and fronts, through the lower 5 km over most of the United States. The usefulness of this cross section in weather forecasting must be obvious to anyone familiar with weather maps. However, the purpose of this paper is only to explain the method of procedure, and not to discuss the results of this work. Extended experience is necessary before such a discussion of results can be satisfactory.

Besides the trouble caused by the frequent delay in the reception of the airplane sounding reports, another unfortunate feature of observations of this kind is that

they are likely to be missing at just the crucial points. Where meteorological action is at a maximum, weather conditions are likely to be such that no flight is made. Consequently on just those days, and in just those regions, where a good cross section would be especially instructive, we are likely to have nothing at all. Since the total number of stations represented on a cross section is very small, the absence of only one or two reports may result in a serious gap in the analysis; and in this type of analysis, just as in that of the surface map, continuity in the analysis from one day to the next is of fundamental importance. This constitutes one serious drawback to the usefulness of the method. It seems as though it should be possible eventually to overcome the present frequent delay in the transmission of the observations; but airplane soundings probably never will be made to an adequate elevation with perfect regularity. However, it is noticeable at the present time that the regularity of the flights, not only at the Army and Navy stations, but also at the Weather Bureau stations, falls far below the high standard set in previous years by such stations as those of the Weather Bureau at Dallas and Omaha. Probably the final solution of this difficulty will be found in the development of cheap and efficient radio-sounding instruments. This improvement would effect not only much greater regularity, but also much greater altitude.

## METEOROLOGY AND CLIMATOLOGY IN A TEACHERS COLLEGE

By G. E. HARDING

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The chief purpose of this discussion is to present a brief survey of meteorology as it is taught today in colleges for the preparation of teachers. The material used in this paper has its principal sources in the writer's association with the curriculum building of the course used in the State of Pennsylvania, and in several years of experience in presenting the subject to the students of the State Teachers College at California, Pa. The data used for surveys outside the State of Pennsylvania are credited to W. C. Jacobs of the University of Southern California, who has made a careful survey of instruction in meteorology in the various colleges and universities of the United States.

In the preparation of a course for use in the teachers colleges, the author should attempt to give the student an insight into the physical processes and laws underlying the many different phenomena of weather and climate. The course should be designed primarily to lay a foundation for a more or less detailed study of climate and its relation to man. Since meteorology is admittedly a physical science it would seem most logical for it to be offered in the science departments along with physics and chemistry. In the survey made by Jacobs, it was found that in 46 percent of the cases meteorology was placed in the geography departments; 17 percent in the department of geography and geology; and only 8 percent in the department of physics. In only four colleges was meteorology allotted a department of its own. In the teachers colleges of Pennsylvania no such course has been delegated to the science departments, but it has been placed in the departments where courses in geography are offered.

Since 1930 meteorology has been included in our curriculum under the title of meteorology and climatology. In most teachers colleges, meteorology finds a place as a correlated subject with geography. In Penn-

sylvania it has been offered as an introduction to the study of the climates of the world, because the basic or fundamental principles set forth in meteorology serve well as an introduction to a systematic study of climatology. In offering the combined course of meteorology and climatology it has been found reasonably satisfactory to introduce the meteorological part with the physics and chemistry of the air. By this is meant the physical characteristics of the air and its chemical composition, and their variations. No attempt should be made to introduce the technical phases of the subject. Enough should be presented to challenge thought and to give a clearer and better approach to the study of climate.

Many students who elect this course have not had training adequate to pursue the more technical discussions of meteorology. In many instances the writer has known students who did not take a course in meteorology because they felt they had not had sufficient prerequisites for the work. That might be one of the reasons why so few have seriously considered courses in the field of meteorology. In a survey of 737 students enrolled in a teachers college it was found that all had had a course in general science during their high-school training. Of these, 262 had had at least 1 course in physics; and 487, or over one-half, a course in chemistry. It is interesting to notice the relatively small percentage who had a course in physics. It is not uncommon to hear a student who has the opportunity to pursue a course in meteorology say, "I can't take that, for I have not had enough work in physics and chemistry."

In the teachers college of Pennsylvania a course in meteorology and climatology is offered as a free elective for any student or as an elective for students who elect geography as one of their majors. In the survey made by Jacobs it was found that of the 252 courses offered, over one-half could be placed in the two major groups

of meteorology proper and climatology. The former represented 38 percent of the number of courses and the latter 33 percent. The rest belonged to miscellaneous or combination courses.

The course as prescribed by the State syllabi is defined as follows: Meteorology and climatology consists of a systematic study of physics of the air and a description of the different climatic regions of the earth. It sets up a number of objectives consistent with the above definition, which are briefly as follows:

1. To learn the fundamental physical aspects of the atmosphere, basic for an understanding of climate.
2. To acquire a working knowledge of the principles of climatology.
3. To develop skill in the reading of climatic maps and graphs.
4. To understand the importance of daily weather and climatic conditions to individuals.
5. To become aware of the climatic conditions under which we live.
6. To acquire sufficient knowledge to correctly interpret natural adaptations of animal and plant life.

The meteorological portion of the work is emphasized in the first part of the course under the following main topics: (1) The solar system; (2) the earth as a part of the solar system; (3) the atmosphere.

The major part of the time is given to the study of the atmosphere, which is divided into four main topics: (1) Composition; (2) pressure; (3) temperature; (4) precipitation and humidity.

The composition of the air serves to introduce the study of the atmosphere. Attention is given to the percentages of the different gases which compose the air at different altitudes.

Since our study has in mind man and his activities, it is obvious that a course in meteorology should attempt to point out as far as possible the physiological effects of the atmosphere. Also, variations in the composition of the atmosphere excite human response, nor can any man escape their influences. Indeed in many parts of our own country the populace is extremely concerned about the composition of the atmosphere, especially as regards dust, water vapor (humidity), gases, etc. Furthermore, when so much is being said today about the effects of solar radiation, it seems advisable to emphasize the screening effects that the atmosphere has upon the light rays from the sun.

Temperature and pressure must receive considerable attention, for they are basic in the study of climate. Thermometers and barometers are studied as to kinds and uses; and in as many instances as possible, the laboratory is used to demonstrate the various instruments. Most colleges do not have what would be considered adequate equipment to properly teach the subject, since the viewpoint of special schools today is toward professionalism. No teachers college can attempt to teach a professional course in meteorology and climatology, but many can offer enough to help the student acquire a

better understanding of climate and climatic responses. Enough is included in the Pennsylvania course on temperature and pressure to produce a clear understanding of the circulation of the atmosphere. Every teacher of geography and general science finds it necessary to have an understanding of the principles of air movements in order to teach about the wind belts of the earth and their effects. Much of the more technical phases of air movements is not needed in a course for the average teacher, for so much of it is of no practical use to him. Concrete problems and exercises should be used in connection with the study of pressure and temperature.

After a study of barometers, as to kinds and uses, attention is given to the representation of pressure on maps and charts. Isobaric surfaces and pressure slopes are introduced and studied. Insofar as possible, the pressure gradient is considered in respect to its influence on wind velocities.

Weather maps showing isobars for annual, seasonal, and daily periods of time are used freely. It has been found that there are certain graphic publications which include data for preparing maps and graphs, and which, when used by the student, serve well to acquaint him with the various pressure belts of the world. The wind belts of the world are considered in respect to their origin, the areas over which they occur, and their effects upon man.

Precipitation and humidity demand thoughtful consideration as prerequisites to the study of the different climates of the world. Special attention is given to the control of humidity. The various methods and instruments used in determining humidity are, as far as possible, at the disposal of the members of the class. Some time is given to the study of clouds and fogs in their relation to precipitation and sunshine. They are intimately associated with radiation and are in part control factors of temperature, and help to determine the environment of man. Dews and frosts are discussed sufficiently to show that they are important enough to command some attention.

The brief course in meteorology serves to introduce a study of the climates of the world. The early part of the course in climatology is used to present the distinct basic types of climates, together with the recognized standard classifications due to (1) Supan, (2) Köppen, (3) Herbertson, (4) Jones and Whittlesey, etc. Each classification is considered with respect to its basis for the climatic divisions. In the State of Pennsylvania it seems the Jones and Whittlesey classification is the one most frequently chosen for a detailed study. Each division of this classification is considered separately. Maps, temperature graphs, rainfall graphs, etc., are made and studied. The responses in each case are given special consideration, even to the preparation of product maps and compilation of various data. The writer has found it profitable to require the making of certain climatic maps from data furnished by the Government of the United States or by the governments of the various States.

## ANALYSIS OF A WARM "COLD FRONT"

By A. H. CHRISTENSEN

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The airway forecaster has an exceptionally favorable opportunity to study the peculiar action of fronts at first hand. His maps drawn at frequent intervals sometimes reveal, along the cold front, unusual action which at first sight appears entirely opposite to the manner in which a normal front should and does act. Such a case was observed by the writer on October 26, 1933, when the weather along several hundred miles of a cold front cleared up some 50 miles in advance of the wind-shift line and remained practically clear during the passage of the shift, contrary to the usual occurrence of turbulent convection and low overcast skies. Careful study of the conditions involved showed that they were exceptional, and that the apparently unusual action was exactly what should be expected under the circumstances.

The original barometric distribution was a trough extending from Minnesota southwestward to the Texas Panhandle, with a rather well-defined, nearly straight, surface wind-shift line extending from western Iowa to the Texas Panhandle. This line was, of course, advancing eastward, and at 7 a. m. of October 26 had not yet passed Omaha. West of this line the winds aloft above 2,000 feet were nearly all northwest up to 12,000 feet. East of this line they were mostly southwest, but with some west winds at certain levels in Texas and Oklahoma.

By 11 a. m. the front had passed Tarkio, Mo., and Waynoka, Okla., but had not reached Wichita, Kans., nor St. Joseph, Mo. At that time generally cloudy weather with mist, light rain and light fog, and ceilings varying from 400 feet to 4,000 feet existed on the eastern side of the trough, over eastern Oklahoma, southeastern Kansas, and most of Missouri except the northwest corner. In this sector the cloudy, rainy weather kept the temperatures in the middle forties. On the polar side the early morning temperatures had been in the forties, but since only scattered to broken high clouds, mostly of the cirrus type, prevailed on that side of the front, there was a material rise in the surface temperature due to insolation. The temperatures there rose from the upper forties to 60° or higher, which was a strong indication of an inversion existing in the early morning. Both the Dallas and Omaha airplane flights showed morning inversions, and apparently the inversion on the eastern side was maintained during the day by the cloudy condition.

Clearing was first noted on the 11 a. m. map, when stations a considerable distance in advance of the surface wind-shift reported scattered clouds where they had previously reported overcast with ceilings below 2,000 feet. Wichita at that time reported a south wind, and strato-cumulus clouds from the northwest.

The clearing continued in advance of the front on the 3 p. m. map. At 2:42 p. m. Kansas City reported clouds from the northwest at an elevation of about 2,500 feet above the surface, but the surface wind did not shift to northwest until 4:30 p. m. or about 2 hours later. The velocity remained around 5 or 6 miles per hour, and it is obvious that such lag in the surface wind-shift was not due to surface drag.

By measurement on successive maps it was determined that the front advanced about 240 miles in 12 hours or approximately at the rate of 20 miles per hour. Since the wind shifted at the 2,500-foot level about 2 hours earlier than at the surface, it follows that if the front advanced at the same rate aloft (a logical assumption) the front at the 2,500-foot level was some 40 miles ahead of the surface wind-shift. The balloon observation at Kansas City at 4:38 p. m. (a few minutes after the surface wind-shift) showed that the wind-shift had passed at all levels up to 12,000 feet. The Omaha 5 a. m. balloon observation showed that it had passed at all levels except the lower 2,000 feet, which indicated that the front lagged only in the lower levels.

Visual observations of clouds at Kansas City indicated that the wind-shift occurred aloft far in advance of the surface shift, and cloud movements indicated that the cooler air to the east of the wind-shift (often of tropical origin, but in this case returning polar air) extended under the warmer polar air in a wedge shape similar to the manner in which polar air usually invades equatorial air. Doubtless this was due to the greater density of the northward moving modified polar air, as its temperature was kept down by the cloudy condition existing on this side, that is to the east of the wind-shift line. Earlier observations in the day indicated that clouds existed to a level of at least 4,000 feet, and very likely these higher clouds cleared away first as the comparatively dry polar air replaced the more moist modified polar air; and breaks began to appear in the lower clouds (which were at an altitude of about 2,500 feet) while the wind at that level was still southwest. As the clearing took place the wind at the lower cloud level shifted to northwest, and about 2 hours later shifted at the surface. Meanwhile the temperature was rising and reached its maximum point at about the time of the surface wind shift.

Ordinarily, strong convection and turbulence would result from the polar air flowing in aloft first; but in this case the temperature of the air in the under levels had been lower than that of the polar air until the clearing occurred, when it apparently rose to about the same value as that of the surface polar air; and there was, of course, no strong lapse rate to produce convection.

While the conditions described above are unusual, they are not so rare as to be considered entirely abnormal. Fronts with important features similar to those described, but also with variations, occur often enough in the middle west for conclusions drawn from an analysis of this kind to be of value in actual forecast work. A front of the kind described can be detected from the wind-aloft reports, combined with surface reports, and temperatures on the two sides of the front line. By a careful estimate of rate of movement of the front, the time of clearing conditions in a case of this kind can be forecast with considerable accuracy for several hours in advance, once the condition has been properly analyzed by the forecaster.

## RELATION OF TROPICAL CYCLONE FREQUENCY TO SUMMER PRESSURES AND OCEAN SURFACE-WATER TEMPERATURES

C. L. RAY

[Weather Bureau, San Juan, P. R.]

A correlation of summer and autumn tropical disturbances in the Caribbean Sea and Gulf of Mexico with spring-summer pressure deviations at San Juan was worked out at the beginning of the current (1934) season. The results were of interest in that the well-defined positive pressure sequence, dating this year from April, indicated the probability of a less than normal frequency of disturbances during the June–November period. This relation was found to apply particularly to the eastern Caribbean, due probably to the more direct influence of the northeast winds in the southeast portion of the oceanic high, and indirectly and possibly more significantly to low surface-water temperature of the north equatorial current in comparison with that of the extreme western Caribbean and Gulf. Practically the distinction between East and West Caribbean formations probably is not very important, since many of the storms originating in or east of the eastern portion of the section eventually cross to the Gulf and affect that region to as great an extent as, if not greater than, do those that start in the immediate Gulf or Central American waters. However, it was found that in approximately 30 percent of the 48 years of record, 1887–1934, a season of plus storm frequency in one area was accompanied by less than normal activity in the other, and vice versa. A partial explanation for this disagreement is the lesser chance offered for a subnormal season in the west portion, owing to the small normal number (2.5) of its storms. Thus a season to be considered below normal here must record but two storms, whereas in the eastern portion the normal of 4.3 permits a greater leeway. The highest frequencies which have occurred in the western Caribbean and Gulf in the 48 years of record, 1887–1934, were 9 storms in 1933; 6 in 1912 and 1924; 5 in 1893, 1909, 1932; and 4 in 1892, 1895, 1906, 1922, 1926, and 1934 (estimated). In the same period a frequency of 3 storms occurred on 9 occasions. The general probability of less than a normal frequency is 56 percent for the west portion compared with 60 percent for the eastern Caribbean.

In the correlations made at the beginning of the season, a 35 year period, 1899–1933 was used as the basis, inasmuch as pressure data prior to 1899 were not available from the San Juan records. In the present paper however, as indicated, a 48-year period is used, for which supplementary pressure data from 1888–98 were taken from Port au Prince and for 1887 from Port of Spain, Trinidad. The addition of these years and 1934 has given the results greater dependability without changing materially the original conclusions. The method pursued in the arrangement of the data was to group the years or seasons into 2 or 3 divisions, according to the pressure obtaining during the months of April to July, inclusive: (1) All years of positive deviations; (2) years of pressure deficiency; (3) variables, where 2- or 3-month sequences were being classified. In the 48 years, 27 percent of the period, representing minus pressures in May, June, and July, accounted for 41 percent of the tropical disturbances, while 33 percent of the period, representing pressures above normal, yielded but 25 percent of the total number. Variable pressures, comprising 40 percent of the 48 years, made up the remaining 34 percent of the 324 recorded disturbances of 1887–1934 (data for 1934 partly estimated). This recapitulation gives a general indication of the results

shown in greater detail in tables 1 and 2, viz, (a) a fairly well-defined connection between positive spring-summer pressures in the North Atlantic and low storm frequencies in the eastern Caribbean and to a lesser extent in the western Caribbean; (b) increased frequencies following pressure deficiencies; (c) lower frequencies after variable pressures than in (b) but more than in (a). Similar correlations were worked out, using the pressure characteristics of single months, May, June, July, or combinations of two consecutive months, April–May, May–June, June–July. However as approximately 60 percent of the same data are duplicated in each of the correlations, there are no very material differences in the several resulting values, with the exception that somewhat better probabilities for the western Caribbean are obtained from the May and May–June pressure characteristics. Generally considered, the May–June–July basis appears the more satisfactory key to (1) the eastern Caribbean situation and (2) the entire area as a unit, by indicating more nearly the pressure control of the autumn months. With respect to the western Caribbean and Gulf, however, the verification is but 62 percent, compared with 90 percent for the eastern Caribbean and 80 percent for the entire area. In general, as stated, the May–June or May pressure alone appears to more consistently indicate west Caribbean and Gulf conditions. The May pressure yielded a verification in 17 years out of 24 after plus pressure deviations, or 71 percent; and the May–June minus sequence verified in 12 years out of 17, likewise 71 percent. The mean verification using May pressure is 66 percent compared with 64 percent for the May–June basis.

A sequence of three spring-summer months of like pressure sign occurs on the average in 2 years out of 3. In the 48-year period, there were 29 such examples. Under such well-defined high- or low-pressure conditions, the indications of summer and autumn storm frequency is rather definitely shown. Where the pressure in these months is variable, the problem is less determinate, although we find that with respect to the eastern Caribbean a positive pressure in July has indicated subnormal storm frequencies in 24 years out of 30, or an average of 80 percent, and a minus pressure in the same month was followed by increased or above normal frequency in 13 out of 18 years, or 72 percent. For the entire area, including west Caribbean and Gulf, the same basis yielded a 73 percent probability, or 74 percent after plus pressure and 72 percent following a minus characteristic.

Of the 42 disturbances originating in the eastern Caribbean area or North Atlantic in the 16 years of positive summer pressures, only a small percentage followed a southerly course through the Caribbean Sea. The great majority formed to the east or northeast of the Leeward Islands, mean position of first location latitude 18°–40°, longitude 57°–30°; and mean recurve at latitude 26°–50°, longitude 80°. These points would not vary greatly in all probability from mean values for the entire record, but the comparative freedom from tropical disturbances of the more southerly portion of the area during years of excess pressure in the North Atlantic is marked. On the other hand several severe storms have been recorded in these years of otherwise favorable conditions, as in September 1908, over Turks Island; and August 1927 in

the North Atlantic, which eventually caused losses on the Canadian coast. Several noteworthy storms that have become important matters in Puerto Rico history, ancient and more recent, might not have been indicated by the summer pressures of those years. The San Ciriaco storm of August 1899 was preceded by positive pressures in May and June, becoming deficient in July. The year was one of less than normal frequency, but San Ciriaco had one of the most severe disturbances in the history of the island. In 1928 the San Felipe storm was of a comparable destructive character; and that it caused less loss of life was due to the advance warnings rather than to any lesser destructive force. Summer pressure preceding this storm was deficient in May and June, but equaled the normal in July. In 1887 the greatest number of disturbances recorded in 1 season occurred, a record until the 21 storms of 1933. In that year, judging from pressures at Port of Spain, Bermuda, and Nassau, there was a deficiency in May and June, followed by a positive departure in July. These instances emphasize the fact that only general indications may be obtained from the pressure deviations of the early months; and each season must necessarily still be watched for developments of the exceptional.

A correlation was made of surface ocean water temperatures of the August to October period with tropical storm frequencies of the eastern Caribbean, using as a basis the years 1920-33, inclusive. A marked positive relation was found in these years, represented by a verification of 87 percent. Accepting the San Juan air temperature as a base, which has been found to be rather closely related to the surface water temperature of the Caribbean, a similar correlation was made, covering the 35-year period, 1899-1933, which yielded a positive value of 72 percent. In this connection, C. F. Brooks writes in the *Monthly Weather Review* of October 1920 as follows (1):

Water colder than usual in this region (Caribbean Sea) would not only reduce the moisture content of the air, but also, by keeping the air cooler, would reduce the usual intensity of development of the low pressure that marks this region in the warm half of the year, and therefore prevent the attainment of the usual strength of the convectional currents.

The relation of the trades to pressure and temperature deviations and storm frequencies was similarly considered. In an earlier study it was noted that the trades influence on ensuing pressure and temperature is most closely related to the wind movement of the January-to-March period, months of relatively high velocities. The temperature of the ocean surface water is affected in the Caribbean Sea after a lag of some months, and is found to be best defined after a 9-month interval, though persisting perhaps for 15 to 18 months or longer. The inverse relation of these winter trades to the August-to-October ocean temperature of the following year is verified in 80 percent of the years of record. The same relation applied to the air temperatures at San Juan yielded 77 percent. The results derived from a comparison of the trades and the summer temperatures of the same year was less well defined. These relations have been limited to the eastern Caribbean. Summer surface water temperatures in the western Caribbean and Florida Straits are normally higher than in the eastern Caribbean, being more directly affected by the temperature of the south equatorial current and by their contiguity to the warmer continental coasts. In this fact may be one explanation for the lack of agreement of storm frequencies in some years in the two divisions.

A quantitative correlation of the winter trades with the pressure after a lag of 9 months gives a coefficient of

+0.31, after 12 months +0.37, and after 16 months (May, June, July period of the following year) +0.53. The strengthening of the ocean high over a period of 18 months or longer after increased winter trades activity explains in part the persistence of definite weather types in the sub-Tropics and likewise the relation of the trades directly and indirectly to tropical storm frequency. A correlation of the winter trades with eastern Caribbean storms of the following year is verified in 83 percent of the years of record. A wind movement of the trades 10 percent above the normal in January, February, or March was used as the dividing line, or point of demarcation between excessive and subnormal conditions.

The inverse effect of an intensified high-pressure area in the North Atlantic on the frequency of tropical storms was noted by E. H. Bowie, in *MONTHLY WEATHER REVIEW* of September 1923 (2):

The region of the West Indies and Gulf of Mexico was free from tropical disturbances during the month (September 1923), this being accounted for by reason of the fact that the northeast trades extended well south of the north coast of South America throughout the month.

With respect to the current season, pressure was above the normal after early in the year, while surface-water temperatures of the Eastern Caribbean indicated subnormal conditions, based upon deficiencies in the San Juan air temperature in July, August, and September. The general probability of a subnormal storm frequency was therefore well defined with respect to the eastern Caribbean and also for the west portion, though verification in past years in the latter area is approximately 20 percent less definite. Excessive trades in February and March 1933 were apparently being reflected in the strengthened summer HIGH over the ocean, while the completion of a May to July positive pressure sequence at San Juan placed the season in that group which from the previous records of 47 years had averaged 2.6 storms for the eastern Caribbean and 2.5 in the west Caribbean and Gulf. The opposition of the latter section, noted frequently in past years, was again exemplified by the occurrence of two rather severe disturbances in the Gulf early in the season and several less well developed formations later in the season. In the east portion of the Caribbean, however, conditions were generally in line with early indications. Such formations as occurred developed to the east or north of the Leeward Islands and in the warmer waters off the Florida coast, and were not of very marked intensity.

To summarize, it may be said that: (1) Spring and summer pressure deviations in the North Atlantic, as indicated by the pressure at San Juan, have an inverse relation to tropical storm frequencies of the summer and autumn months. This is best indicated where pressure continues above normal from May through July, but is also related definitely to the July departure considered singly, and also as early as April-May. It is less well defined with respect to the west Caribbean, but has a 71-percent probability of verification in relation to the May and June pressure deviation. (2) Ocean temperatures bear an inverse relation to storm frequency in the tropics based upon results of a 15-year period of surface water temperatures 1920-34 (values for 1934 interpolated). (3) Trade winds of the winter months have a correlation coefficient of +0.53 with the pressure over the North Atlantic 16 months later and, therefore, are closely related to tropical storm frequencies of the following year. The trades also have an inverse relation to the temperature of the ocean surface water temperatures, best defined after a lag of 9 months, but continuing after an interval of 12

months and possibly beyond. (4) The probability of storm frequency based upon summer pressures refers more especially to departures from a normal of 2.5 storms for the west Caribbean and Gulf, and 4.3 for the eastern Caribbean. As regards intensity of individual storms, no general rule is indicated, although a greater proportion of mild formations appear to occur in years of increased pressure in the summer months.

## REFERENCES TO LITERATURE CITED

(1) The Relation of Prolonged Tropical Droughts to Sun spots, by W. H. Pickering, Mo. WEA. REV., Oct. 1920 (including comments by Dr. C. F. Brooks).

(2) Forecasts and Storm Warnings, E. H. Bowie, Mo. WEA. REV., Sept. 1923.

TABLE 1.—Correlation of tropical storm frequencies of the Caribbean and Gulf and spring-summer pressures at San Juan P. R. (1887-1934)

| Pressure   | Number of seasons | Tropical storm frequencies |                |              |                |                 |                |               |                |                 |                |               |                |
|--|-------------------|----------------------------|----------------|--------------|----------------|-----------------|----------------|---------------|----------------|-----------------|----------------|---------------|----------------|
|  |                   | West Caribbean and Gulf    |                |              |                | East Caribbean  |                |               |                | Entire area     |                |               |                |
|  |                   | Below normal               |                | Above normal |                | Below normal    |                | Above normal  |                | Below normal    |                | Above normal  |                |
| April-May:<br>Plus.....<br>Minus.....<br>Variable.....     | 16<br>13<br>19    | No.<br>10<br>11            | Pct.<br>62<br> | No.<br>8<br> | Pct.<br>62<br> | No.<br>14<br>10 | Pct.<br>88<br> | No.<br>10<br> | Pct.<br>77<br> | No.<br>12<br>10 | Pct.<br>75<br> | No.<br>10<br> | Pct.<br>77<br> |
| Mean.....  | 48                | 62 percent                 |                |              |                | 82 percent      |                |               |                | 76 percent      |                |               |                |
| May:<br>Plus.....<br>Minus.....                            | 24<br>24          | 17<br>24                   | 71<br>         | 15<br>       | 62<br>         | 20<br>          | 83<br>         | 16<br>        | 67<br>         | 18<br>          | 75<br>         | 15<br>        | 62<br>         |
| Mean.....  | 48                | 66 percent                 |                |              |                | 75 percent      |                |               |                | 68 percent      |                |               |                |
| May-June:<br>Plus.....<br>Minus.....<br>Variable.....      | 17<br>17<br>14    | 10<br>17<br>14             | 58<br>         | 12<br>       | 71<br>         | 15<br>10        | 88<br>         | 14<br>        | 82<br>         | 12<br>11        | 71<br>         | 13<br>        | 76<br>         |
| Mean.....  | 48                | 64 percent                 |                |              |                | 85 percent      |                |               |                | 74 percent      |                |               |                |
| June-July:<br>Plus.....<br>Minus.....<br>Variable.....     | 21<br>15<br>12    | 12<br>15<br>12             | 57<br>         | 9<br>        | 60<br>         | 17<br>10        | 81<br>         | 14<br>        | 94<br>         | 14<br>11        | 67<br>         | 13<br>        | 87<br>         |
| Mean.....  | 48                | 58 percent                 |                |              |                | 86 percent      |                |               |                | 77 percent      |                |               |                |
| May-June-July:<br>Plus.....<br>Minus.....<br>Variable..... | 16<br>13<br>19    | 9<br>13<br>19              | 56<br>         | 9<br>        | 69<br>         | 14<br>14        | 88<br>         | 12<br>        | 92<br>         | 11<br>15        | 69<br>         | 12<br>        | 92<br>         |
| Mean.....  | 48                | 62 percent                 |                |              |                | 90 percent      |                |               |                | 80 percent      |                |               |                |
| July:<br>Plus.....<br>Minus.....                           | 30<br>18          | 18<br>18                   | 60<br>         | 8<br>        | 44<br>         | 24<br>          | 80<br>         | 13<br>        | 72<br>         | 22<br>          | 74<br>         | 13<br>        | 72<br>         |
| Mean.....  | 48                | 52 percent                 |                |              |                | 76 percent      |                |               |                | 73 percent      |                |               |                |
| General probability.....                                   |                   | 56                         | 44             | 60           | 40             | 56              | 44             |               |                |                 |                |               |                |

TABLE 2.—Mean frequency of tropical disturbances, of Caribbean and Gulf of Mexico, in relation to spring-summer pressure at San Juan, P. R. (1887-1934)

| Pressure       | West Caribbean and Gulf |           | East Caribbean        |           | Entire area           |           |
|----------------|-------------------------|-----------|-----------------------|-----------|-----------------------|-----------|
|                | Average number storms   | Departure | Average number storms | Departure | Average number storms | Departure |
| April-May:     |                         |           |                       |           |                       |           |
| Plus.....      | 2.3                     | -0.2      | 2.6                   | -1.7      | 4.9                   | -1.9      |
| Minus.....     | 3.2                     | +0.7      | 6.1                   | +1.8      | 9.3                   | +2.5      |
| May:           |                         |           |                       |           |                       |           |
| Plus.....      | 2.0                     | -0.5      | 2.8                   | -1.5      | 4.8                   | -2.0      |
| Minus.....     | 2.9                     | +0.4      | 5.5                   | +1.2      | 8.4                   | +1.6      |
| May-June:      |                         |           |                       |           |                       |           |
| Plus.....      | 2.5                     | 0.0       | 2.6                   | -1.7      | 5.1                   | -1.7      |
| Minus.....     | 3.1                     | +0.6      | 6.2                   | +1.9      | 9.3                   | +2.5      |
| June-July:     |                         |           |                       |           |                       |           |
| Plus.....      | 2.5                     | 0.0       | 3.0                   | -1.3      | 5.5                   | -1.3      |
| Minus.....     | 3.0                     | +0.5      | 6.7                   | +2.4      | 9.7                   | +2.9      |
| May-June-July: |                         |           |                       |           |                       |           |
| Plus.....      | 2.5                     | 0.0       | 2.6                   | -1.7      | 5.1                   | -1.7      |
| Minus.....     | 3.4                     | +0.9      | 6.9                   | +2.6      | 10.3                  | +3.5      |
| July:          |                         |           |                       |           |                       |           |
| Plus.....      | 2.2                     | -0.3      | 3.2                   | -1.1      | 5.4                   | -1.4      |
| Minus.....     | 2.7                     | +0.2      | 5.7                   | +1.4      | 8.4                   | +1.6      |
| Normal.....    | 2.5                     |           | 4.3                   |           | 6.8                   |           |

TABLE 3.—Annual frequency of tropical storms in the Caribbean and Gulf of Mexico, 1887-1934

| Year | West Caribbean | East Caribbean | Year | West Caribbean | East Caribbean | Year | West Caribbean | East Caribbean | Year | West Caribbean | East Caribbean |
|------|----------------|----------------|------|----------------|----------------|------|----------------|----------------|------|----------------|----------------|
| 1887 | 3              | 13             | 1899 | 2              | 3              | 1911 | 1              | 1              | 1923 | 1              | 4              |
| 1888 | 3              | 7              | 1900 | 1              | 5              | 1912 | 6              | 2              | 1924 | 6              | 2              |
| 1889 | 3              | 5              | 1901 | 2              | 8              | 1913 | 2              | 2              | 1925 | 2              | 1              |
| 1890 | 0              | 1              | 1902 | 3              | 1              | 1914 | 1              | 1              | 1926 | 4              | 6              |
| 1891 | 2              | 9              | 1903 | 0              | 8              | 1915 | 1              | 4              | 1927 | 1              | 6              |
| 1892 | 4              | 5              | 1904 | 3              | 6              | 1916 | 3              | 10             | 1928 | 0              | 6              |
| 1893 | 5              | 5              | 1905 | 2              | 1              | 1917 | 0              | 2              | 1929 | 1              | 1              |
| 1894 | 2              | 4              | 1906 | 4              | 5              | 1918 | 0              | 4              | 1930 | 0              | 2              |
| 1895 | 4              | 2              | 1907 | 1              | 3              | 1919 | 1              | 3              | 1931 | 3              | 5              |
| 1896 | 3              | 3              | 1908 | 2              | 4              | 1920 | 2              | 2              | 1932 | 5              | 6              |
| 1897 | 2              | 3              | 1909 | 5              | 7              | 1921 | 3              | 2              | 1933 | 9              | 12             |
| 1898 | 2              | 5              | 1910 | 1              | 3              | 1922 | 4              | 1              | 1934 | (4)            | (3)            |

Figures in parentheses estimated.

TABLE 4.—Years of pressure excess or deficiency at San Juan, P. R., during May, June, July, 1887-1934<sup>1</sup>

| Pressure     |              |
|--------------|--------------|
| Above normal | Below normal |
| 1890         | 1888         |
| 1892         | 1889         |
| 1895         | 1891         |
| 1896         | 1893         |
| 1908         | 1901         |
| 1910         | 1903         |
| 1912         | 1906         |
| 1913         | 1915         |
| 1914         | 1916         |
| 1917         | 1926         |
| 1922         | 1931         |
| 1923         | 1932         |
| 1924         | 1933         |
| 1927         |              |
| 1929         |              |
| 1934         |              |

<sup>1</sup> Data 1887, Port of Spain, Trinidad; 1888-98 from Port au Prince, Haiti.

## RELATION OF MAY-JUNE WEATHER CONDITIONS IN JAMAICA TO THE CARIBBEAN TROPICAL DISTURBANCES OF THE FOLLOWING SEASON

By J. F. BRENNAN, Government Meteorologist

[Kingston, Jamaica, B. W. I., January 1935]

The island of Jamaica is near the southwestern limit of the zone exposed to the August and September hurricane tracks.

If the observations during the 3 months of May, June, and July, as given in table 1, be studied, it will be obvious that, in most cases, when the island mean rainfall is excessive, the mean surface wind below the daily normals, and the daily mean barometric pressure below the normal, there is much likelihood of the development of disturbed weather conditions in the eastern Caribbean, particularly during the ensuing months of August and September. Conversely, when during the same 3 months the island mean rainfall is deficient, the mean surface wind above the daily normals, and the daily mean barometric pressure consistently above the normal, there is little likelihood of disturbances occurring in the following months of August and September.

If the years 1903, 1915, 1916, 1932, and 1933, when there was considerable storm activity, be selected, it will be evident that from May to July the mean island rainfall was above the normal, the mean surface wind deficient and the mean barometric pressure below the normal, as shown in table 1 (a) and reproduced in table 2.

By referring to table 3, extracted from table 1 (b), quite the opposite indications are presented. The years 1907, 1920, 1922, 1929, and 1934 belong to a group of periods which may be identified as being devoid of hurricanes or as having very little storm activity.

The two groups (tables 2 and 3) extracted from table 1, may be regarded merely as sufficient to demonstrate the possible existence of antecedent causes, during the 3 months preceding the hurricane season, or they may be taken as governing factors to indicate the character of the forthcoming storm period.

Tables 2 and 3 are not exhaustive, but only examples; table 2 may be added to by including the year 1931, when the rainfall total, May to July, was 33.03 inches, which is over 50 percent above the normal. The wind, 187 miles per day, was equivalent to 83 percent of the normal of 225 miles. The barometric pressure was 29.903 inches, or 0.013 inches below the 33-year average. During the year 1931 there was a storm of some intensity on August 13, passing to the south of Jamaica and moving westward.

The year 1925 also might have been included in table 3, when the rainfall was deficient, wind above the normal, and the barometric pressure above the normal. Under such conditions there should be expected an absence of hurricanes, and none was reported.

Consequently, there appears to be some evidence that at least 12 out of 29 years furnished definite indications of the coming storm conditions in August and September.

In the foregoing tables it will be noted that in 2 and 3 the mean low pressure and high pressure are deduced from 3 consecutive months (May to July, 92 days).

During this period, for each year, there existed several individual days having fluctuations of pressure of both low and high. It is thus only the general means for these combined 3 months which appear to be the governing factors; individual days of high or low pressure do not appear to be important.

The line AB of figure 1 is the mean 29.90-inch isobar for May, June, and July. South of this line the pressure is less; north of it greater.

Daily observations at the point marked X are needed as it is just possible that the general mean high or low pressure departures (during the 3 months mentioned) are determined in that area more than in Jamaica. It is notable that the isobars for the months of August and September lie nearly on the lines of average hurricane tracks in these tropical waters.

As there is no likelihood, at present, of establishing a suitable station for surface observations at X, the only



FIGURE 1.

course left is to await results for coming years before attempting to determine expected weather in August and September from surface data. It would be unwise and premature to issue forecasts to the public until the matter receives further investigation.

The preceding tables of surface observations may be supplemented by a brief statement of the character of the upper air observations, at Kingston, in the year 1929, when there was an absence of hurricanes, and in the year 1933 when there was abnormal activity in the Caribbean region: In the year 1929, from May to July, the wind velocity at altitudes about 1,000 to 2,500 meters showed, consistently, an excess over the 10-year averages; and in the year 1933 there was the opposite, for the upper air velocity fell below the normals. This corresponded with the changes in the surface wind records; the velocity of the wind at certain altitudes reflects its force and direction near the surface.

TABLE 1.—Amount of rainfall, mean daily miles of wind and mean barometric pressure during the combined months of May, June, and July 1903 to 1934

| Year     | Combined total rainfall for 3 months | Combined mean daily miles of wind for 3 months | Mean daily barometric pressure for 3 months |
|----------|--------------------------------------|--|---|
|          | Normal for 60 years 20.00 inches     | Normal for 25 years 225 miles                  | Normal for 33 years, 29.934 inches          |
|          | Inches                               | Miles  | Inches                                      |
| 1903 (a) | 20.93                                | 220  | 29.919                                      |
| 1907 (b) | 15.34                                | 196  | 29.945                                      |
| 1908     | 20.74                                | 194  | 29.958                                      |
| 1909     | 18.78                                | 183  | 29.943                                      |
| 1910     | 16.54                                | 178  | 29.960                                      |
| 1911     | 17.34                                | 238  | 29.953                                      |
| 1912     | 11.33                                | 267  | 29.951                                      |
| 1913     | 16.34                                | 225  | 29.956                                      |
| 1914     | 14.80                                | 249  | 29.951                                      |
| 1915 (a) | 24.16                                | 230  | 29.910                                      |
| 1916 (a) | 29.44                                | 191  | 29.907                                      |
| 1917     | 20.88                                | 207  | 29.944                                      |
| 1918     | 21.22                                | 210  | 29.927                                      |
| 1919     | 22.30                                | 243  | 29.927                                      |
| 1920 (b) | 15.74                                | 240  | 29.937                                      |
| 1921     | 22.17                                | 225  | 29.929                                      |
| 1922 (b) | 11.79                                | 263  | 29.947                                      |
| 1923     | 14.54                                | 273  | 29.930                                      |
| 1924     | 16.17                                | 222  | 29.939                                      |
| 1925     | 14.78                                | 230  | 29.941                                      |
| 1926     | 13.76                                | 213  | 29.928                                      |
| 1927     | 19.20                                | 220  | 29.953                                      |
| 1928     | 14.64                                | 241  | 29.930                                      |
| 1929 (b) | 12.32                                | 257  | 29.958                                      |
| 1930     | 15.47                                | 244  | 29.938                                      |
| 1931     | 33.03                                | 187  | 29.903                                      |
| 1932 (a) | 22.54                                | 213  | 29.903                                      |
| 1933 (a) | 31.46                                | 207  | 29.908                                      |
| 1934 (b) | 15.69                                | 237  | 29.936                                      |

NOTE.—The years denoted by (a) in this table are reproduced in table 2, so as to group together the periods of abnormal hurricane activity; and those denoted by (b), years of no hurricanes or but few, table 3.

The above table is derived from (1) the publication entitled "The Rainfall of Jamaica" 60-year period, page 30, and subsequent Jamaica Weather Reports years 1930 to 1934, (2) the Jamaica Weather Report No. 689, Table (C) p. 9, giving the Kingston daily mean total miles of Wind, and (3) the mean barometric pressures from the 7 a. m. and 3 p. m. daily observations, as shown in the respective printed Jamaica Weather Reports, 1903 to 1934.

TABLE 2.—5 years of instances (during the period from 1903 to 1934) when the months of May, June, and July indicate abnormal conditions of rainfall, surface wind, and barometric pressure, favorable to hurricane activity during the months of August and September, in the Caribbean region

| Year | Combined total rainfall for 3 months | Combined mean daily miles of wind for 3 months | Mean daily barometric pressure for 3 months |
|------|--------------------------------------|--|---|
|      | Normal for 60 years, 20.00 inches    | Normal for 25 years, 225 miles                 | Normal for 33 years, 29.934 inches          |
|      | Inches                               | Miles  | Inches                                      |
| 1903 | 20.93                                | 220  | 29.919                                      |
| 1915 | 24.16                                | 220  | 29.910                                      |
| 1916 | 29.44                                | 191  | 29.907                                      |
| 1932 | 22.54                                | 213  | 29.903                                      |
| 1933 | 31.46                                | 207  | 29.908                                      |

TABLE 3.—5 years of instances (during the period from 1903 to 1934) when the months of May, June, and July indicate abnormal conditions of rainfall, surface wind, and barometric pressure, favorable to the absence of hurricane activity, during the months of August and September, in the Caribbean region

| Year | Combined total rainfall for 3 months | Combined mean daily miles of wind for 3 months | Mean daily barometric pressure for 3 months |
|------|--------------------------------------|--|---|
|      | Normal for 60 years, 20.00 inches    | Normal for 25 years, 225 miles                 | Normal for 33 years, 29.934 inches          |
|      | Inches                               | Miles  | Inches                                      |
| 1907 | 15.34                                | 196  | 29.945                                      |
| 1920 | 15.74                                | 240  | 29.937                                      |
| 1922 | 11.79                                | 263  | 29.947                                      |
| 1929 | 12.32                                | 257  | 29.958                                      |
| 1934 | 15.69                                | 237  | 29.936                                      |

## THE DROUGHT OF 1933-34 IN NEW MEXICO

By MARSHALL J. CHAMBERS

(Weather Bureau, Albuquerque, N. Mex., January 1935)

One definition of drought is: "A continued lack of rainfall so long as to very seriously affect vegetation in a region where the average rainfall and its seasonal distribution normally are sufficient to sustain plant growth and produce crops." Various other definitions of drought have been used, but none of these covers the situation in New Mexico quite so well as the one just given.

The normal course of precipitation in New Mexico is a gradual increase from a minimum in January to a maximum in July and August, followed by a gradual decrease to November. This is considerably modified, however, by the heavy snowfall which occurs at higher mountain elevations during winter and spring months. The amount of snowfall shows a fairly uniform rate of increase with altitude, being about 30 inches annually at 7,000 feet; 50 inches from 8,000 to 9,000 feet; 100 inches at 10,000 feet; and, at a few stations at the crest of the Sangre de Cristo range, more than 200 inches. Normally much of this snow accumulates at the high levels, where it melts in late spring and early summer and furnishes water used for irrigation of the fertile lower-valley lands.

The 1933-34 drought was by far the most severe of any in the history of the State. There have been periods when less precipitation was received but never before a drought when temperatures remained so consistently high for so long a time. It is difficult to exactly date the beginning of this drought, but in terms of

whole months, deficient precipitation began with September 1933.

During the following winter and spring there was but slight snowfall. February received the largest fall, 80 percent of its average amount, while December, commonly the month of greatest depth, had but 35 percent, and the entire season only 52 percent, of the normal. The scant snow cover was further reduced by the prevalence of unusually high temperatures, which caused excessive melting that resulted in a greatly reduced depth of stored snow at the close of the season.

Precipitation closely approximated the seasonal trend to the close of January 1934, although the amounts were considerably lower than usual. Of the following months, only May gave precipitation that averaged slightly above the normal, and this was due to the occurrence of thunder showers in the last decade. These showers were very local in character and of brief duration, and the little moisture absorbed by the soil was soon dissipated by the excessive heat of the last 4 days of the month. June gave 42 percent and July 52 percent of the normal precipitation.

Average monthly mean temperatures were well above the normal from the beginning of June 1933 through August 1934. During this period, the months of September and October 1933 and May and July 1934 were the warmest of record. The latter gave the highest average mean temperature ever observed in the State.

Some 20 individual station records of heat were broken, and the extreme heat record for the State ( $116^{\circ}$ ) was equaled.

Water, impounded in reservoirs for irrigation, became increasingly low. Early in August 1934 Elephant Butte Reservoir reached its lowest known level, while Lake Avalon, Carlsbad Lake, and Bluewater Lake became dry. The Canadian, Pecos, and Rio Grande were dry a few miles below their source, and for the first time within the memory of the oldest inhabitants many mountain streams and springs failed to provide water for stock.

Stream flow, in the largest streams of the State, was the second lowest of record, that of 1903-04 (the water year is Oct. 1 to Sept. 30) being slightly less. Records of only three key stations are available, but these closely approximate conditions at other points within the State.

The average annual run-off of the Canadian River at Logan is about 175,000 acre-feet. Normally about 100,000 acre-feet pass this point during the spring season, April 1 to June 30. The total run-off for the year 1933-34 was 49,298 acre-feet, and of this amount only 3,370 acre-feet passed during the spring season. The river was dry at this point from March 10 to August 20, except for a few periods of short duration following rains. The greatest monthly run-off was 21,600 acre-feet in September; and the least, none, in April.

The average annual run-off of the Rio Grande at Embudo is about 800,000 acre-feet. Some 60 percent of this amount, or nearly 500,000 acre-feet, normally passes between April 1 and June 30. The spring run-off in 1934 was 30,785 acre-feet, and the total for the year 282,090. The greatest monthly amount was 38,960, in February; and the least, 12,840, in July.

The average annual run-off of the Rio Grande at the Otowi Bridge, near San Ildefonso, is about 1,500,000 acre-feet, and the spring run-off average about 900,000. The total for the year 1933-34 at this point was 413,990 and for the spring 129,780. The greatest monthly flow was 70,080 in April, and the least 13,550 in July.

A unique and interesting circumstance in providing water for irrigation of fields in the Middle Rio Grande Valley was the use of drainage water from lands adjacent to the Rio Grande.

The Middle Rio Grande Conservancy District has 344 miles of drainage canals, which normally develop from 800 to 1,250 second-feet of water. This water is conveyed in drains to the river, and picked up (less losses) in the various headings of the irrigation canals below. At five points in the valley, direct diversion of the drain water is made into irrigation canals. This involves checking up the drains from 2 to 5 feet to raise the water high enough to reach the elevation of the irrigation ditches, and in some cases the building of a section of canal to make the connection. At two points approximately 50 second-feet can be diverted in this manner with normal flows in the

drains, and at other points less amounts. Owing to the drought this season the flow was somewhat diminished and the low point was reached in the middle of August when it dropped to about 250 second-feet. During the first half of May a small amount of water passed down the river. After about May 15 no water passed Los Lunas; after June 1 none passed Albuquerque. From that date all the water used from Isleta south to Elephant Butte Reservoir was returned drain water, until the August rains.

All the lands south of Isleta would have been without water for  $2\frac{1}{2}$  months had it not been for the drain water; and between Isleta and Bernalillo a large percentage of the irrigation depended upon the drain flow. The county agent for Bernalillo County states that the crops this fall are about 75 percent of the normal. If there had been no water available from the drains the crops would have been only 25 percent of normal or less.

The most conservative methods possible were followed in using the water for irrigation. Each farm was allotted a certain number of second-feet, determined by the amount of water available and the number of acres under cultivation. The flow was maintained for a specified number of hours, after which it was allotted to the next farm under the system. Farmers were notified in advance as to the exact time water would be turned into their ditches, the amount, and the number of hours it would be available. This gave opportunity to acquire extra help, if necessary, to use the water most advantageously.

No attempt has been made to estimate the cost of the drought. Millions of acres of land remained idle. Many other millions of acres were planted but failed to make a crop. In the eastern plains section of the State, top soil was blown from fields and carried until some obstruction, usually a fence, was reached. There the soil was deposited, gradually piling up, until it reached a depth of 4 to 10 feet. Thousands of miles of fences in this section were buried until not a trace remained visible. It will require many years of hard work to bring these farms back to their predrought status.

Figures compiled by the Director of Drought Relief show that 400,000 head of cattle were purchased before the end of October. Purchases were to be continued throughout the winter, although on a smaller scale. A program for the purchase of sheep and goats was also gotten under way in early autumn. Many thousands of both cattle and sheep perished before the purchasing program was inaugurated.

Ranges have reached the worst condition of record, and while heavy rains or snows will cause them to revive in most sections, there are large areas, notably in eastern counties, where the grass roots are dead and the passage of several seasons probably will be required to fully restore new growth.

EXCESSIVE HEAT AND THE DEATH RATE IN KANSAS<sup>1</sup>

By S. D. FLORA

[Weather Bureau Office, Topeka, Kans.]

A new record for deaths in Kansas, due to excessive heat, since statistics became available, was established last summer, according to the report of Dr. Earle G. Brown, Secretary of the State Board of Health. July 1934 was the hottest month of record in this State, which at times is subject to intense heat waves, and the climb of the death rate from heat was remarkable.

A total of 206 deaths was reported from this cause during the month as compared with 33 in July 1931, which had previously held the record. For the summer as a whole, 430 deaths from heat were reported, which is at the rate of 22.6 per 100,000 population. The previous record for any summer was 75 in 1931, but reliable mortality statistics in Kansas do not extend back to the hot summer of 1901. The total of accidental deaths from all causes in July also was the highest on record for any month, due, doubtless, to increase in outdoor recreation, such as motoring, swimming, and picnicking generally.

During the 12-day period, July 10 to 21, when all-time heat records were broken in most parts of the State, there were 113 fatal heat strokes, or 55 percent of the total for the entire month.

<sup>1</sup> See also "Maximum temperatures and increased death rates in the drought area in 1934" by S. D. Collins and M. Gover. Reprint from U. S. Public Health Reports, Vol. 49, No. 35, August 31, 1934, pp. 1015-1018.—Editor.

Sixty-five percent of the summer's heat deaths were of persons 65 years old, or older, and were about equally divided between the sexes. Of the heat strokes, 186 were classified as originating in the home. There were but 13 occupational deaths and seven of these originated in connection with agriculture.

During July there were 10 deaths of children under five years of age, 4 of persons 5 to 14 years old, 57 in age group 26 to 64 years, and none in the age group 15 to 24 years. Included in the 10 children under 5 years were 9 infants. Excluding these infants, the average age of the remaining 197 persons was 69.6 years.

Excessive heat as a cause of death was, apparently, far more effective in cities than in rural sections. There were 114 deaths in cities of more than 2,500 population, compared with 92 in smaller towns and rural sections. A majority of the deaths from excessive heat occurred in the eastern third of the State, where most of the larger cities are located and where the humidity is higher, the nights warmer, and the wind movement less, though maximum temperatures are not likely to be as high there as farther west. Only 19 of the heat deaths were reported from the western half of the State.

## A USEFUL HYGROMETRIC CALCULATING DEVICE

By LESLIE G. GRAY

[Fire Weather Service, Weather Bureau, San Francisco, Calif.]

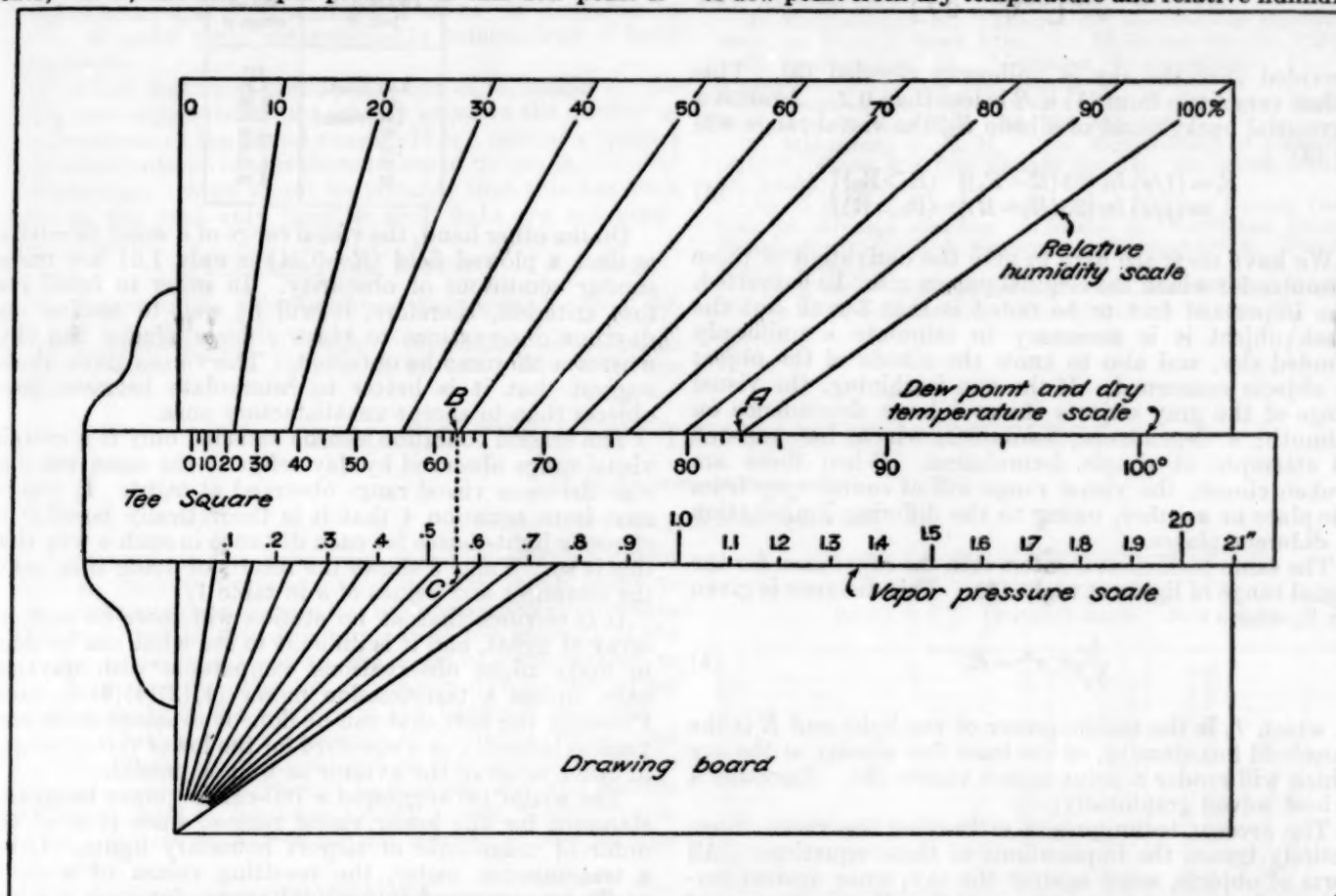
The figure shows schematically a graphical computing device, designed to expedite the calculation of various hygrometric factors; the necessity for consulting tables is eliminated, provided that one of the known factors is relative humidity, dew point or vapor pressure, thus taking care of the elevation (air pressure) factor. The device was used to permit rapid computation of more than 350,000 dew points in connection with fire weather data summarizations by O. W. A. and F. E. R. A. personnel, which otherwise would have been computed laboriously from tables. When tables are used, the work progresses very slowly, since the wet bulb depression must be found, tables appropriate to the station elevation must be used, several pages usually have to be turned to find the proper place, and care must be taken to follow down and across vertical and horizontal columns of figures, respectively, to find proper values. If wet bulb temperatures are not available, the wet bulb depression must be found from tables by a reverse process, and the proper table must then be consulted for the desired value, using the depression so found. The graphical device, however, permits rapid determination of dry temperature, given relative humidity and dew point or vapor pressure; of relative humidity, given dry temperature and dew point or vapor pressure; or of dew point or vapor pressure, given dry temperature and relative humidity; as well as several other combinations. The use of one previously computed value (as relative humidity or dew point) takes care of the elevation factor; and the degree of accuracy of the results depends on the size of the scales and the accuracy of their construction. Since straight lines are used throughout, no great drafting skill is required to construct this device.

The device consists of an ordinary drawing board and T-square, to each of which are fastened suitable scales. The drawing board scale represents relative humidity by lines drawn from a common center, and so spaced that along any horizontal line represented by the edge of the T-square blade, equal intervals of humidity are represented by equal distances. As thus prepared, the network of lines represents a system for dividing into equal parts a horizontal line of any length within its range. The horizontal line is provided by the edge of the T-square blade, on which a scale of vapor pressure by equal intervals is laid off. Opposite appropriate saturation vapor pressures on this scale, a scale of temperature is laid off, the temperatures thus corresponding to dew points at the same dry temperatures and 100 percent relative humidity. By definition, relative humidity is given by the actual vapor pressure (equivalent to a dew point) divided by the saturation vapor pressure at the given dry temperature (the dew point for 100 percent relative humidity). These considerations are independent of station elevation.

In use, the only special precaution to be observed with the device is to keep the head of the T-square firmly against the edge of the drawing board. Prior to use, the zero of the vapor pressure scale on the blade should be tested for coincidence throughout with the zero relative humidity line on the drawing board by sliding the square up and down. For example, as shown in the figure, suppose the dry temperature is 82.8° and the relative humidity 50 percent, required the dew point and vapor pressure. Slide the T-square up or down the board until the dry temperature on the edge of the blade coincides with the 100 percent relative humidity line, as at A. With this setting, representing to scale the satura-

tion vapor pressure for a temperature of 82.8°, each humidity line cuts the blade vapor pressure and temperature scales at proportional points. In this case, 50 percent relative humidity cuts the dew point scale at 62.6°, at B, and the vapor pressure at this dew point is

The device possibly may be useful at some airways stations in rapidly computing relative humidity from dry temperature and dew point, as given in hourly observations; and at fire weather stations, for calculating values of dew point from dry temperature and relative humidity,



0.567 inch, at C. If the dry temperature again is 82.8°, and the dew point 23°, without changing the setting, it is apparent that the relative humidity is 10 percent. In other words, as set in this example, the device shows every related hygrometric factor (except wet bulb temperature or wet bulb depression) for a dry temperature of 82.8°.

on form 1009-E. All necessary data for construction of the scales appears in the dew point and equivalent vapor pressure columns of W. B. Pub. No. 235, Psychrometric Tables by C. F. Marvin.

## THE PRINCIPLES UNDERLYING THE CHOICE OF VISIBILITY MARKS<sup>1</sup>

By W. E. KNOWLES MIDDLETON

[Meteorological Service of Canada, Toronto, Ontario, December 1934]

The estimation of the distance of visibility, or "visual range", by eye is probably one of the least satisfactory of all meteorological observations. Quite apart from the excellence or otherwise of the observer's eyesight, it must be recognized that this element depends to a large extent upon the nature of the marks at which he can look.

What are the criteria of a satisfactory method of determining the visual range? Surely they cannot be very different from those which apply to any other observation; we shall suggest two:

(1) Observations made at different stations shall be intercomparable.

(2) Observations made by night shall be comparable with those made by day.

It will be the purpose of this note to suggest procedures by means of which these conditions may at least be approximated.

It has been shown (6) (7) (8) that the visual range of a black object against the horizon sky is given by the formula

$$S_v = \frac{1}{\sigma} \ln 50 = \frac{3.912}{\sigma} \quad (1)$$

where  $\sigma$  is the extinction coefficient<sup>2</sup> of the atmosphere in the horizontal. This formula is independent of azimuth, and holds if the sky is cloudless or completely clouded.

<sup>1</sup> The extinction coefficient is defined by the equation  $dE = -\sigma E dx$ ,

where  $E$  is the flux-density in a parallel beam of light traveling in the direction of  $x$ . It is a convenient measure of the obscurity of the atmosphere at a given time and place.

<sup>2</sup> Published by permission of the Director of the Meteorological Service of Canada.

A gray object of albedo (diffuse reflection coefficient)  $R$ , seen against the horizon sky has the visual range

$$S = \frac{1}{\sigma} \ln \left[ 50 \left( 1 - \frac{R}{2} \right) \right] \quad (2)$$

provided that the sky is uniformly clouded (3). This differs very little from (1) if  $R$  is less than 0.2. Against a terrestrial background of albedo  $R_1$ , the visual range will be (3)

$$S_1 = \frac{(1/\sigma) \ln [25(R - R_1)]}{(1/\sigma) \ln [25(R_1 - R)]} \quad \begin{matrix} (R > R_1) \\ (R_1 > R) \end{matrix} \quad (3)$$

We have no space here to give the derivation of these formulae for which the original papers must be consulted. The important fact to be noted is that for all but the black object it is necessary to stipulate a uniformly clouded sky, and also to know the albedo of the object or objects concerned. If the sun is shining, the visual range of the gray objects shows a large dependence on azimuth; a dependence, moreover, which has resisted all attempts at simple formulation. When there are broken clouds, the visual range will of course vary from one place to another, owing to the differing illumination in different places.

The same coefficient  $\sigma$  enters into the expression for the visual range of lights at night (3). This distance is given by  $S_n$  where

$$\frac{I_0}{S_n^2} e^{-\sigma S_n} = E, \quad (4)$$

in which  $I_0$  is the candle-power of the light and  $E$  is the threshold flux-density, or the least flux density at the eye which will render a point source visible (9). Equation 4 is best solved graphically.

The present techniques of estimating the visual range entirely ignore the implications of these equations. All sorts of objects, some against the sky, some against terrestrial backgrounds, are used during the daytime; and at night there is a similar lack of care in the choice of lights, with only a warning against observing a beacon (11) or a "powerful lighthouse" (10). The result is that neither of the above criteria is satisfied.

If we restrict our choice of daytime objects to black objects against the sky, it follows from (1) that each value of  $S$ , corresponds to a unique value of  $\sigma$ . It is therefore possible to construct a table showing corresponding values of  $\sigma$  and  $S$ , as in table 1.

TABLE 1

| Extinction coefficient $\sigma$ | Visual range $S$ , of black object | Extinction coefficient $\sigma$ | Visual range $S$ , of black object |
|---------------------------------|------------------------------------|---------------------------------|------------------------------------|
| $km^{-1}$                       | $km$                               | $km^{-1}$                       | $km$                               |
| 78.0                            | 0.050                              | 1.68                            | 2.33                               |
| 36.2                            | .108                               | .780                            | 5.00                               |
| 16.8                            | .232                               | .362                            | 10.8                               |
| 7.80                            | .500                               | .168                            | 23.5                               |
| 3.62                            | 1.08                               | .078                            | 50.0                               |

The reasons for the choice of values in table 1 need not concern us here—they form a geometric progression in  $\sigma$ , and happen to lie near the values in the international code for visibility. The important point is that *when we make an accurate estimate of the visual range of a black object against the sky we are in effect measuring  $\sigma$ , which is a property of the atmosphere.* Even if the object is not

quite black, the difference is not great, as is shown by table 2, as long as it appears against the sky.

TABLE 2.—Visual range of black and dark gray objects for  $\sigma = 1.0 km^{-1}$ 

| Albedo of object, $R$ | Visual range, $S$ |
|-----------------------|-------------------|
|                       | $km$              |
| 0.00 (black)          | 3.91              |
| .01                   | 3.90              |
| .04 (woods)           | 3.88              |
| .07                   | 3.86              |
| .10                   | 3.85              |
| .15                   | 3.82              |
| .20                   | 3.80              |

On the other hand, the visual range of a wood ( $R=0.04$ ) against a plowed field ( $R=0.24$ ) is only 1.61 km under similar conditions of obscurity. In order to fulfill our first criterion, therefore, it will be well to confine our daytime observations to black objects against the sky, wherever they can be obtained. The values given above suggest that it is better to interpolate between good objects than to accept unsatisfactory ones.

The second condition can be satisfied only if a certain visual range observed by day refers to the same value of  $\sigma$  as the same visual range observed at night. It will be seen from equation 4 that it is theoretically possible to choose a light-source for each distance in such a way that this is so. Table 3 shows the results of doing this, using the distances and values of  $\sigma$  in table 1.

It is obvious that at no station will there be such an array of lights, and it is difficult to see what can be done to make night observations comparable with daytime ones, unless a transmission meter (1)(2)(4)(9) is used. Probably the best that can be done is to adopt some convenient intensity as a standard for the lower visual ranges, in order to serve the aviator as well as possible.

The writer (9) suggested a 100-candle power lamp as a standard for the lower visual ranges, since it is of the order of magnitude of airport boundary lights. Using a transmission meter, the resulting values of  $\sigma$  could easily be converted into visual ranges for such a lamp; curves suited to this purpose have been published by Foitzik (3)(5). The aviator could then accept the measurements with the confidence that he could see a boundary light at the distance given by the "visibility" in the weather report.

The objection may be raised that tables 1 and 3 are not strictly comparable because of the variation of  $\sigma$  with the wavelength, the color temperature of incandescent lamps being lower than that of daylight. This is a legitimate criticism at the greater visual ranges; but at the shorter distances the variation of  $\sigma$  becomes much less.<sup>3</sup> Also, since  $\sigma$  for the lamp is always less than for daylight, table 3 is on the safe side as regards the candle power of the necessary lights.

TABLE 3.—Visual range of lights at night

| Extinction coefficient $\sigma$ | Visual range $S_n$ | Intensity of source $I_0$ | Remarks  |
|---------------------------------|--------------------|---------------------------|--|
| $km^{-1}$                       | $km$               | $candl/s$                 |  |
| 78.0                            | 0.050              | 0.04                      | These values of $I_0$ are calculated on basis of $E$ , the threshold of vision, having the value $E=3.5 \times 10^{-7}$ meter-candles or 0.35 lumens $km^{-2}$ . |
| 36.2                            | .108               | .2                        |  |
| 16.8                            | .232               | 1.0                       |  |
| 7.80                            | .500               | 4.4                       |  |
| 3.62                            | 1.08               | 20                        |  |
| 1.68                            | 2.35               | 95                        |  |
| .780                            | 5.00               | 437                       |  |
| .362                            | 10.8               | 2,040                     |  |
| .168                            | 23.5               | 9,500                     |  |
| .078                            | 50.0               | 43,700                    |  |

<sup>3</sup> Evidence for this is to be presented by the writer in a paper to be published in the near future.

We may formulate the general conclusions (1) that for observations in the daytime it is advisable to confine our choice of marks to black, or nearly black, objects against the horizon sky, rejecting marks which appear against terrestrial backgrounds; and (2) that the general adoption of some sort of transmission meter is desirable in order to make night measurements independent of local conditions.

It is felt that some standardization of technique on the lines here suggested would greatly improve the quality of observations of the visual range. It is a common opinion that observations of this element are of no use in synoptic meteorology. May it not be possible that this has been true in the past only because such data are not inter-comparable?

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## CLIMATIC TREND IN THE PACIFIC NORTHWEST

H. G. CARTER, Meteorologist

[Weather Bureau, Boise, Idaho, January 1935]

Numerous studies have been made of weather conditions in various sections of the country in an effort to determine whether climate has undergone any progressive change in one definite direction within the memory of the present generation.<sup>1</sup> With the view of contributing to the data already collected for this purpose, the writer made a study of the weather in the Pacific Northwest.

The Weather Bureau records at Portland, Oreg., and Seattle, Wash., were considered as representative of the coast climate of the Pacific Northwest, and the records at Boise, Idaho; Spokane, Wash.; and Walla Walla, Wash., as representative of the climate of the interior stations.

## PRECIPITATION

Table 1 gives the annual precipitation at each of the five stations from the beginning of the records down to and including 1933, and figure 1 shows graphically the same data. A glance at the chart emphasizes the variations in precipitation from year to year. Wet and dry years follow each other irregularly by no set rule. A study of the chart reveals the difficulty of finding cycles of wet or dry years. At Portland the unusually wet year of 1882 stands in sharp contrast to the dry year of 1929. The annual amounts, when represented in inches, show greater variations at the coast stations, as amounts for the year are larger than at the interior stations. It is interesting to note the frequent similarity in the trend of the graphs representing the amounts at the different stations.

TABLE 1.—Annual precipitation

| Year | Portland | Seattle | Boise | Spokane | Walla Walla |
|------|----------|---------|-------|---------|-------------|
| 1868 |          |         | 6.69  |         |             |
| 1869 |          |         | 15.73 |         |             |
| 1870 |          |         | 15.93 |         |             |
| 1871 |          |         | 25.80 |         |             |
| 1872 | 46.90    |         | 17.33 |         |             |
| 1873 | 50.52    |         | 17.74 |         | 13.13       |
| 1874 | 46.17    |         | 14.97 |         | 11.84       |
| 1875 | 60.10    |         | 13.83 |         | 15.91       |
| 1876 | 54.94    |         | 11.12 |         | 17.32       |

<sup>1</sup> Kincer, J. B.: Is Our Climate Changing? A Study of Long-Time Temperature Trends. *MONTHLY WEATHER REVIEW*, vol. 61, September 1933, pp. 251-259.

TABLE 1.—Annual precipitation—Continued

| Year    | Portland | Seattle | Boise | Spokane | Walla Walla |
|---------|----------|---------|-------|---------|-------------|
| 1877    | 58.30    |         | 13.80 |         | 20.56       |
| 1878    | 47.70    | 42.69   | 9.02  |         | 13.64       |
| 1879    | 62.22    | 56.44   | 15.17 |         | 20.46       |
| 1880    | 51.87    | 42.92   | 10.66 |         | 17.71       |
| 1881    | 57.05    | 46.81   | 13.56 | 24.68   | 22.37       |
| 1882    | 67.24    | 36.71   | 14.43 | 25.90   | 20.87       |
| 1883    | 51.45    | 30.32   | 15.17 | 14.37   | 12.56       |
| 1884    | 38.31    | 30.35   | 21.05 | 20.56   | 20.61       |
| 1885    | 30.59    | 38.25   | 12.56 | 19.01   | 13.31       |
| 1886    | 38.70    | 31.13   | 12.23 | 15.86   | 16.20       |
| 1887    | 54.17    | 35.63   | 11.34 | 20.10   | 20.44       |
| 1888    | 38.76    | 34.77   | 11.09 | 17.69   | 13.59       |
| 1889    | 31.76    | 25.92   | 10.95 | 14.27   | 14.53       |
| 1890    | 40.38    | 26.84   | 12.53 | 16.57   | 11.80       |
| 1891    | 47.41    | 34.74   | 13.31 | 16.69   | 16.11       |
| 1892    | 33.58    | 32.40   | 11.75 | 16.78   | 16.94       |
| 1893    | 39.03    | 45.16   | 13.92 | 22.00   | 23.07       |
| 1894    | 39.32    | 41.08   | 14.12 | 17.84   | 20.49       |
| 1895    | 30.76    | 29.69   | 7.90  | 13.46   | 14.89       |
| 1896    | 44.13    | 42.83   | 22.95 | 20.32   | 19.41       |
| 1897    | 43.01    | 41.53   | 16.98 | 23.84   | 21.67       |
| 1898    | 33.90    | 29.28   | 8.85  | 13.08   | 16.34       |
| 1899    | 42.21    | 37.13   | 14.84 | 20.08   | 22.99       |
| 1900    | 38.22    | 36.48   | 12.77 | 18.72   | 18.89       |
| 1901    | 41.05    | 30.18   | 9.59  | 15.99   | 14.52       |
| 1902    | 50.15    | 45.78   | 12.15 | 19.23   | 18.88       |
| 1903    | 35.62    | 34.55   | 9.55  | 16.55   | 15.70       |
| 1904    | 46.37    | 37.73   | 14.08 | 13.97   | 18.13       |
| 1905    | 34.10    | 34.35   | 9.77  | 16.68   | 17.12       |
| 1906    | 43.29    | 36.67   | 14.19 | 17.60   | 19.13       |
| 1907    | 42.89    | 29.10   | 15.92 | 17.69   | 15.77       |
| 1908    | 34.37    | 28.25   | 12.33 | 12.02   | 11.66       |
| 1909    | 43.75    | 31.72   | 15.06 | 16.21   | 18.73       |
| 1910    | 38.65    | 34.20   | 12.07 | 15.44   | 16.82       |
| 1911    | 33.28    | 21.69   | 15.35 | 11.86   | 13.38       |
| 1912    | 43.47    | 35.14   | 18.10 | 18.21   | 20.36       |
| 1913    | 36.30    | 24.59   | 16.04 | 16.74   | 17.38       |
| 1914    | 36.67    | 31.43   | 8.60  | 13.56   | 13.60       |
| 1915    | 41.30    | 33.83   | 13.31 | 16.35   | 17.08       |
| 1916    | 45.77    | 34.61   | 14.64 | 15.75   | 21.32       |
| 1917    | 40.50    | 28.90   | 14.48 | 11.88   | 15.90       |
| 1918    | 31.50    | 29.21   | 12.73 | 9.92    | 12.25       |
| 1919    | 45.70    | 31.34   | 11.46 | 13.85   | 16.64       |
| 1920    | 41.17    | 32.21   | 13.57 | 12.18   | 18.43       |
| 1921    | 43.21    | 39.81   | 12.07 | 12.62   | 16.41       |
| 1922    | 38.76    | 25.27   | 12.00 | 11.51   | 11.15       |
| 1923    | 32.81    | 27.18   | 12.47 | 16.02   | 17.19       |
| 1924    | 31.22    | 30.73   | 8.66  | 12.25   | 13.06       |
| 1925    | 31.36    | 25.78   | 13.79 | 12.35   | 11.71       |
| 1926    | 41.17    | 26.12   | 11.05 | 14.52   | 17.90       |
| 1927    | 45.78    | 32.98   | 15.41 | 23.28   | 18.51       |
| 1928    | 34.69    | 25.60   | 9.53  | 10.56   | 12.44       |
| 1929    | 26.11    | 20.03   | 8.83  | 7.54    | 11.19       |
| 1930    | 27.16    | 21.78   | 14.46 | 11.84   | 13.22       |
| 1931    | 42.68    | 36.06   | 9.41  | 13.61   | 16.97       |
| 1932    | 39.98    | 34.28   | 13.09 | 15.85   | 14.76       |
| 1933    | 52.85    | 44.91   | 7.95  | 14.91   | 16.22       |
| Average | 42.25    | 33.66   | 13.22 | 16.05   | 16.61       |

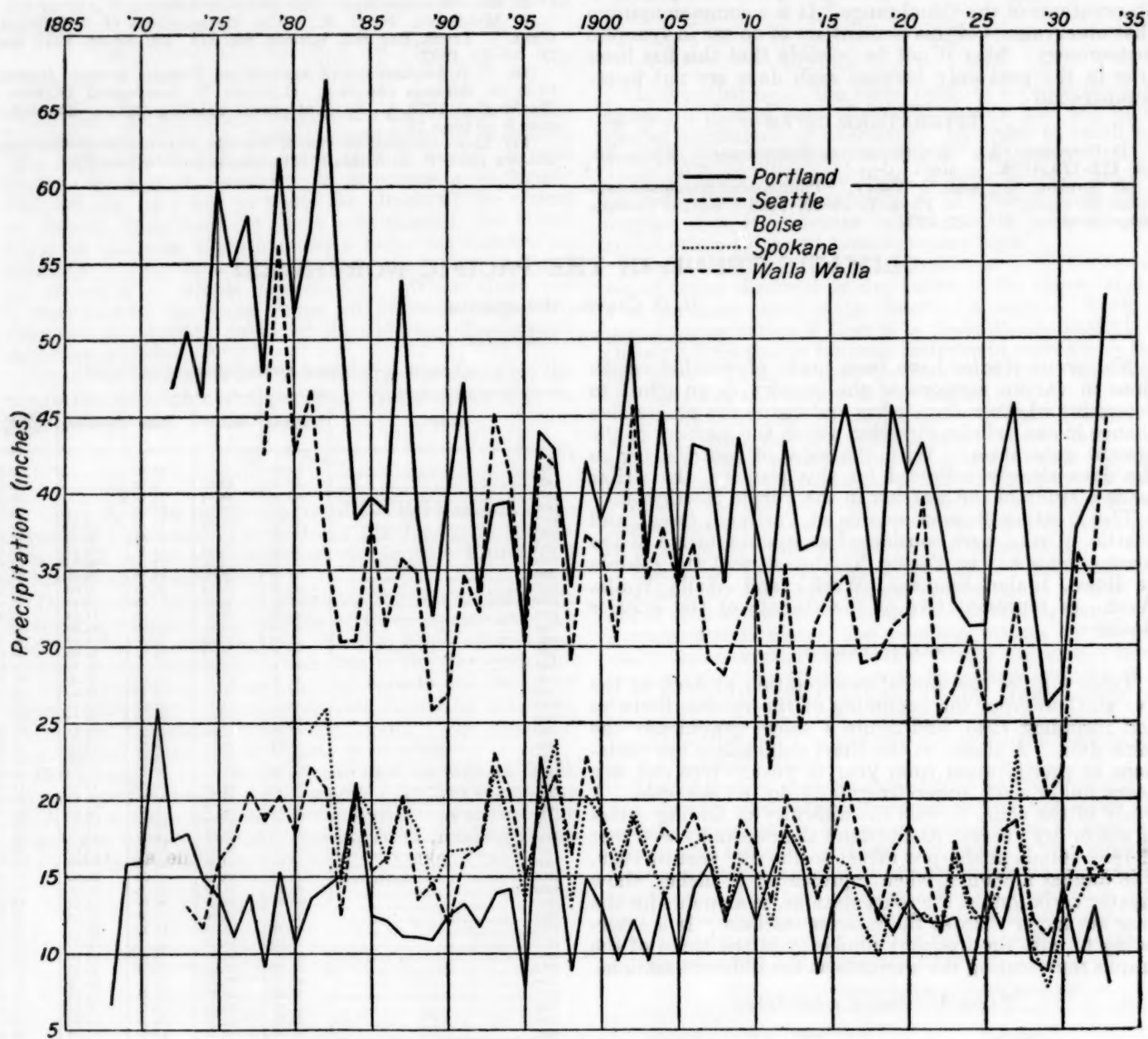


FIGURE 1.—Annual precipitation from the beginning of observations to the end of 1933.

Figure 2 shows sliding 10-year averages of precipitation for each of the five stations. These values were determined by taking the average of 1 year and the preceding 9 years. For example, the value for Portland for 1881 is 53.6 inches; this is the average for the 10 years ending 1881. The value for 1882, 55.6 inches, is the average for the 10 years ending 1882, etc. A uniform downward trend during the last 10 or 15 years is noted for all stations, and for longer periods at some of the stations. The lowest point reached for Portland and Seattle is in 1931; for Boise, 1933; for Spokane, 1926; and for Walla Walla, 1930.

At Portland the wettest 10 consecutive years were 1874 to 1883, when the average rainfall was 55.70 inches, or 132 percent of normal; the driest 10 consecutive years were 1922 to 1931, with an average of 35.17 inches, or 83 percent of normal.

At Seattle, the wettest 10-year group was from 1878 to 1887, with an average of 39.12 inches, or 116 percent of normal; the driest, was from 1922 to 1931, with 27.15 inches, or 81 percent of normal.

At Boise, the wettest 10-year period was from 1869 to 1878, with an average of 15.53 inches, or 117 percent of normal; the driest, from 1924 to 1933, with 11.28 inches, or 85 percent of normal.

At Spokane, the wettest 10-year period was from 1881 to 1890, with 18.91 inches, or 118 percent of normal; the driest, from 1917 to 1926, with 12.71 inches, or 79 percent of normal.

At Walla Walla, the wettest was 1893 to 1902, with 19.12 inches, or 115 percent of normal; the driest, from 1921 to 1930, with 14.28 inches, or 85 percent of normal.

#### TEMPERATURES

Table 2 gives the mean annual temperature for the five stations from the beginning of records up to and including 1933, and the same data are presented graphically in figure 3. A slight upward trend will be observed during the last two decades. Figure 4 shows the sliding 10-year averages. The values used in preparing this chart were obtained in the same manner as that used in obtaining precipitation values in figure 2.

TABLE 2.—Annual temperatures

| Year | Portland | Seattle | Boise | Spokane | Walla Walla |
|------|----------|---------|-------|---------|-------------|
| 1868 |          |         | 50.4  |         |             |
| 1869 |          |         | 54.6  |         |             |
| 1870 |          |         | 52.6  |         |             |
| 1871 |          |         | 52.9  |         |             |
| 1872 |          |         | 53.1  |         | 51          |
| 1873 |          |         | 52.9  |         | 53          |
| 1874 | 53.4     |         | 54.6  |         | 52          |
| 1875 | 53.2     |         | 52.6  |         | 52          |
| 1876 | 53.0     |         | 52.6  |         | 53          |
| 1877 | 53.2     |         | 52.4  |         | 55          |
| 1878 | 53.0     |         | 52.4  |         | 54          |
| 1879 | 52.4     |         | 51.4  |         | 51          |
| 1880 | 50.9     |         | 48.9  |         | 50          |
| 1881 | 52.9     |         | 50.0  | 47.3    | 51          |
| 1882 | 52.7     |         | 48.6  | 46.5    | 51          |
| 1883 | 52.9     |         | 48.7  | 46.8    | 51          |
| 1884 | 52.6     |         | 50.0  | 45.4    | 50          |
| 1885 | 55.6     |         | 52.1  | 50.1    | 56          |
| 1886 | 53.6     |         | 50.8  | 48.7    | 54.4        |
| 1887 | 52.3     |         | 51.4  | 47.2    | 52.9        |
| 1888 | 53.8     |         | 52.0  | 48.7    | 54.2        |
| 1889 | 54.8     |         | 52.2  | 49.1    | 54.3        |
| 1890 | 52.2     |         | 49.3  | 47.4    | 52.8        |
| 1891 | 53.7     |         | 49.5  | 49.0    | 54.2        |
| 1892 | 52.9     | 53.8    | 49.3  | 48.4    | 53.8        |
| 1893 | 50.1     | 50.2    | 48.4  | 45.7    | 50.6        |
| 1894 | 51.9     | 50.4    | 50.6  | 48.2    | 53.0        |
| 1895 | 52.0     | 51.2    | 49.4  | 48.0    | 53.1        |
| 1896 | 52.6     | 51.1    | 50.5  | 48.6    | 53.5        |
| 1897 | 53.1     | 51.5    | 50.9  | 48.2    | 53.1        |
| 1898 | 52.6     | 52.2    | 49.3  | 48.2    | 53.2        |
| 1899 | 51.9     | 51.3    | 50.0  | 47.2    | 52.4        |

TABLE 2.—Annual temperatures—Continued

| Year    | Portland | Seattle | Boise | Spokane | Walla Walla |
|---------|----------|---------|-------|---------|-------------|
| 1900    | 53.5     | 52.8    | 52.5  | 49.8    | 54.4        |
| 1901    | 52.6     | 52.0    | 52.5  | 48.8    | 53.3        |
| 1902    | 52.6     | 52.2    | 51.1  | 47.9    | 52.4        |
| 1903    | 52.9     | 51.2    | 50.8  | 47.5    | 52.5        |
| 1904    | 54.3     | 52.4    | 53.0  | 49.9    | 55.1        |
| 1905    | 53.3     | 51.9    | 50.9  | 48.2    |             |
| 1906    | 54.4     | 52.5    | 51.5  | 49.4    | 54.9        |
| 1907    | 53.6     | 51.1    | 52.0  | 47.6    |             |
| 1908    | 52.9     | 50.9    | 51.0  | 48.8    | 54.2        |
| 1909    | 51.8     | 49.7    | 51.5  | 47.4    | 52.4        |
| 1910    | 53.3     | 50.9    | 51.8  | 49.6    | 53.9        |
| 1911    | 52.2     | 50.2    | 49.7  | 47.8    | 52.9        |
| 1912    | 53.4     | 51.5    | 49.5  | 47.8    | 53.1        |
| 1913    | 52.8     | 50.6    | 49.9  | 46.9    | 52.2        |
| 1914    | 54.4     | 52.2    | 52.1  | 49.6    | 54.2        |
| 1915    | 54.8     | 52.8    | 52.0  | 49.9    | 54.7        |
| 1916    | 51.5     | 49.2    | 49.6  | 45.9    | 50.0        |
| 1917    | 54.0     | 50.8    | 50.8  | 48.6    | 54.3        |
| 1918    | 54.8     | 51.6    | 51.9  | 50.2    | 55.2        |
| 1919    | 52.7     | 50.4    | 50.6  | 47.7    | 52.6        |
| 1920    | 52.9     | 50.6    | 50.5  | 48.7    | 52.8        |
| 1921    | 53.6     | 50.5    | 52.2  | 48.9    | 53.9        |
| 1922    | 52.2     | 49.9    | 50.2  | 47.3    | 52.2        |
| 1923    | 54.5     | 51.9    | 51.2  | 49.0    | 54.2        |
| 1924    | 53.7     | 51.5    | 50.7  | 49.1    | 53.7        |
| 1925    | 55.3     | 52.6    | 53.0  | 51.1    | 56.5        |
| 1926    | 56.8     | 54.0    | 53.4  | 50.6    | 56.0        |
| 1927    | 53.8     | 51.5    | 51.4  | 48.0    | 53.3        |
| 1928    | 54.1     | 52.2    | 51.6  | 49.5    | 54.0        |
| 1929    | 53.2     | 50.9    | 50.0  | 47.2    | 51.9        |
| 1930    | 53.2     | 51.3    | 50.2  | 48.7    | 52.7        |
| 1931    | 55.2     | 52.8    | 52.0  | 50.0    | 54.4        |
| 1932    | 54.2     | 51.7    | 50.3  | 48.7    | 53.8        |
| 1933    | 53.4     | 51.6    | 51.7  | 49.0    | 54.5        |
| Average | 53.3     | 51.5    | 51.2  | 48.4    | 53.2        |

At Portland the warmest 10 consecutive years were 1923 to 1932 (fig. 4) with an average annual temperature of 54.4°, while the coldest were 1893 to 1902, with an average annual mean of 53.2°. At Seattle the warmest 10 consecutive years were 1923 to 1932, with an average mean of 52°, and the coldest were 1913 to 1922, with a mean of 50.9°. At Boise, the warmest 10 consecutive years were 1869 to 1878, with a mean of 53.1°, and the coldest were 1890 to 1899, with a mean of 49.7°. At Spokane, the warmest were 1924 to 1933, with a mean of 49.2°, and the coldest were 1881 to 1890, with 47.7°. At Walla Walla, the warmest were 1917 to 1926, with 54.1°, and the coldest 1875 to 1885, with 51.8°.

When considered by seasons, the data indicate that the springs have been getting warmer during recent years at all five stations. Summers were cooler at Boise during the last 10-year period, but at other stations they were warmer during the last 2 decades, and at Portland, Seattle, and Walla Walla during the last 3 decades.

Autumns show but little change during the latter part of the record, Portland, Seattle, and Boise being slightly warmer, Spokane slightly cooler, while at Walla Walla there was but little change.

The average recent winter temperatures show no change at Portland. At Seattle, Walla Walla, and Spokane they were slightly higher than during the preceding 10 years, while at Boise they were lower.

The data presented in this paper, while indicating the weather of the past, is not to be considered necessarily as an indication of that for the future, except that the usual trend of weather, after a period of departures from normal conditions, is to again swing back to normal. The moderately warm and relatively dry weather of the past decade or so in the Pacific Northwest, is abnormal, and if future conditions follow past performances, it would appear reasonable to expect a return to normal conditions. The data are not to be interpreted as indicating an indefinite continuation of temperatures above normal and precipitation below normal.

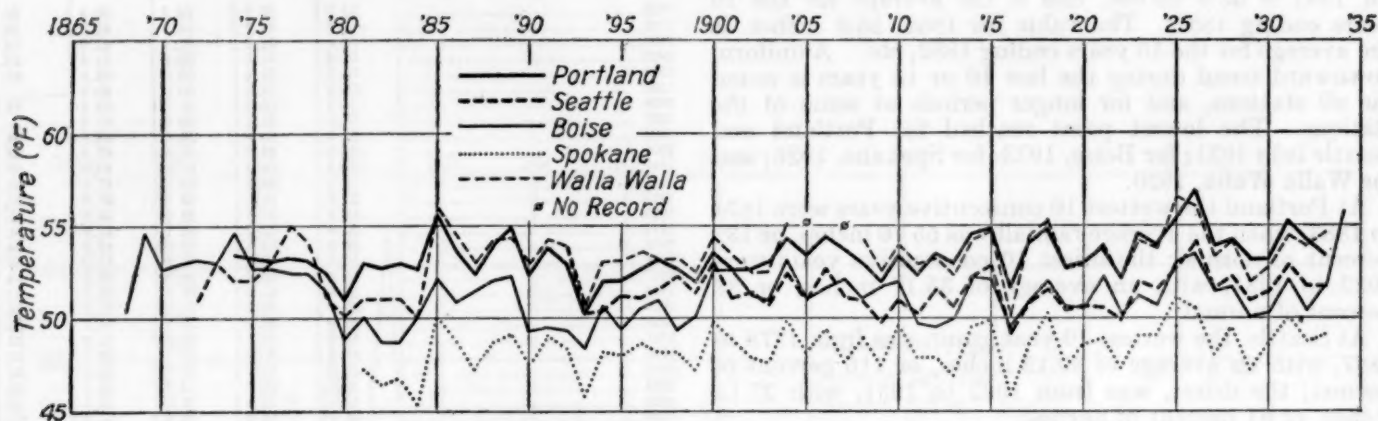


FIGURE 2.—Sliding 10-year precipitation averages from the beginning of observations to the end of 1933.

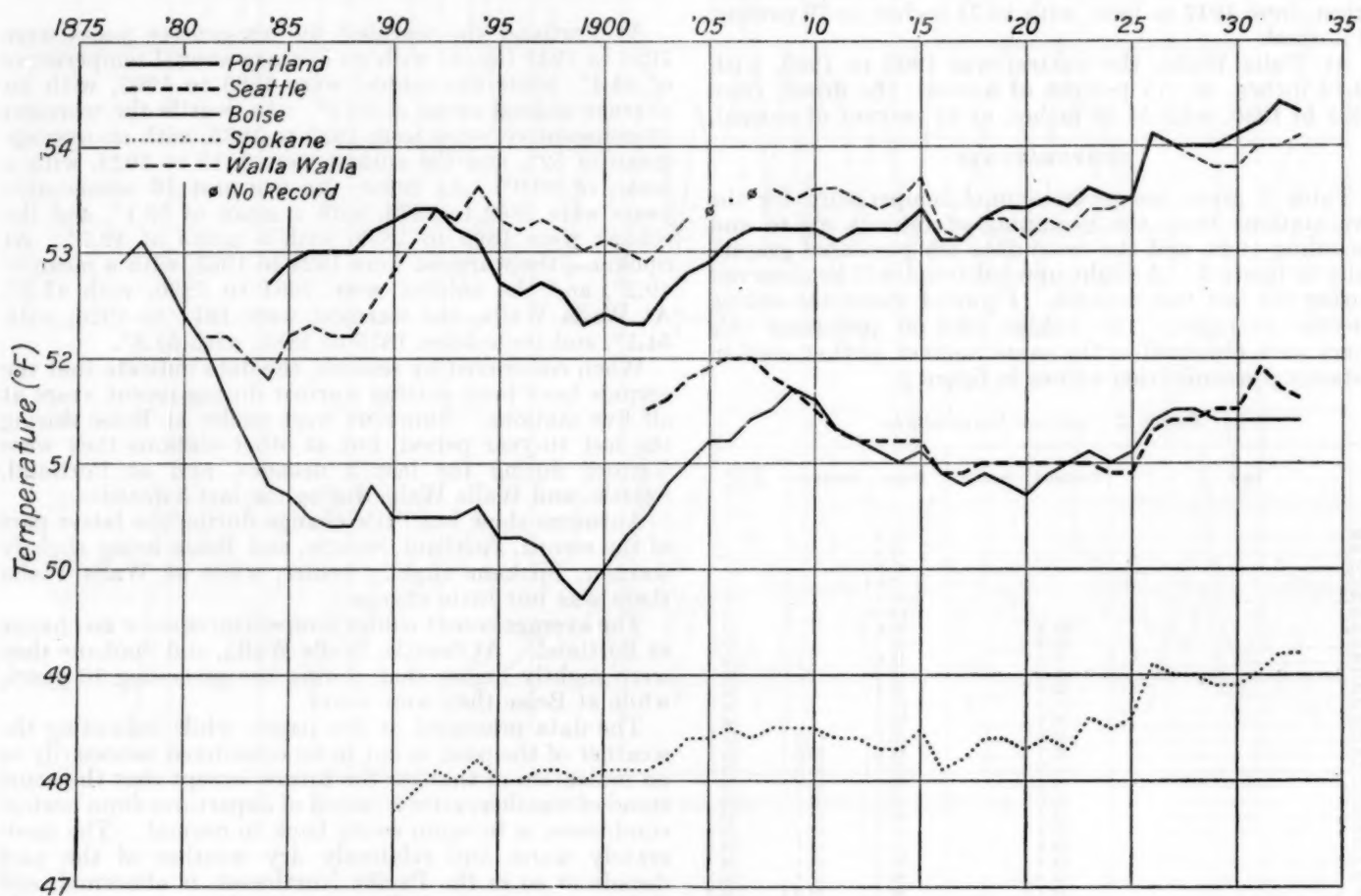


FIGURE 3.—Mean annual temperatures (F.) from the beginning of observations to the end of 1933.

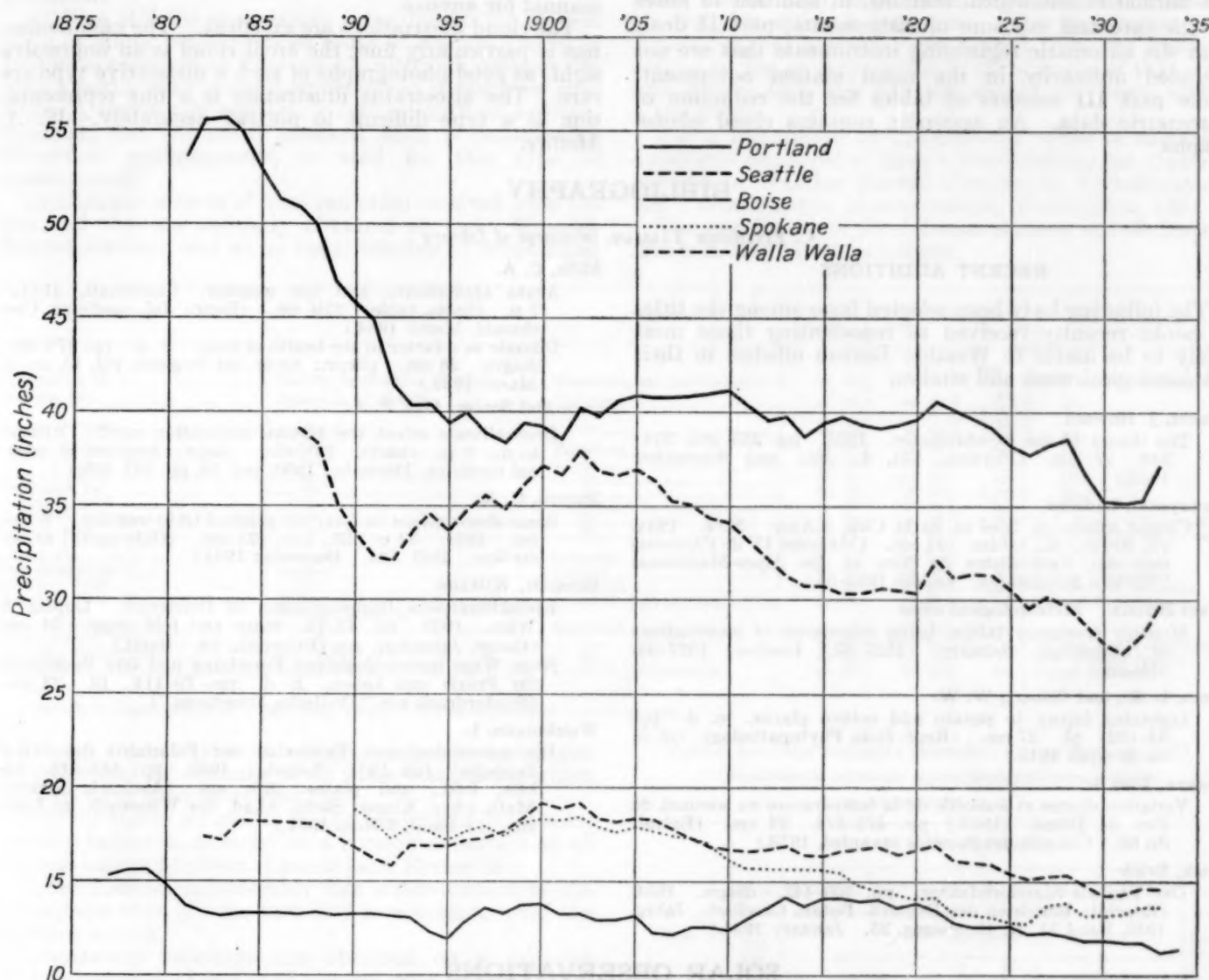


FIGURE 4.—Sliding 10-year mean annual precipitation averages from the beginning of observations to the end of 1933.

## METEOROLOGICAL OFFICE—THE OBSERVER'S HANDBOOK, LONDON, 1934

[Review]

This book illustrates what can be done in the way of compactness without sacrifice of necessary detail. It is the latest addition to a distinguished series; the earlier volumes were called "Instructions for Meteorological Observers."

The book is divided into three main sections: Part I contains instructions for making routine observations at the normal climatological stations, in addition to notes on the care and exposure of instruments; part II deals with the automatic registering instruments that are not included ordinarily in the usual station equipment; while part III consists of tables for the reduction of barometric data. An appendix contains cloud photographs.

The plan of the volume is excellent; it combines instructions for the care, operation, and exposure of the various instruments with details of the proper methods of taking observations; and, in addition, includes many interesting items of information as to the "why" of certain procedures. The system of designating and classifying stations differs from that of the United States Weather Bureau; but the Handbook is a useful reference manual for anyone.

The cloud illustrations are excellent. The cumulonimbus is particularly fine; the anvil cloud is an impressive sight, as good photographs of such a distinctive type are rare. The altostratus illustration is a fine representation of a type difficult to portray accurately.—W. A. Mattice.

## BIBLIOGRAPHY

C. FITZHUGH TALMAN, in charge of Library

## RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Arnold, J. Howard

The theory of the psychrometer. 1933. pp. 255-262, 334-340. 27 cm. (Physics. Vol. 4. July and September 1933.)

Gorczynski, Ladislas

Climat solaire de Nice et de la Côte d'Azur. Nice. 1934. vii, 208 p. ill., tables. 24 cm. (Mémoire IV de l'Association des Naturalistes de Nice et des Alpes-Maritimes. "Riviera Scientifique," années 1933-34.)

Great Britain. Meteorological office

Monthly frequency tables, being summaries of observations of horizontal visibility. 1927-33. London. 1927-34. 31½ cm.

Jones, L. R., and Gilbert, W. W.

Lightning injury to potato and cotton plants. n. d. pp. 94-102. pl. 27 cm. (Repr. from Phytopathology, vol. 5, no. 2, April 1915.)

Lagaye, Jean de

Variation diurne et annuelle de la température au sommet du Puy de Dôme. [1933.] pp. 472-474. 24 cm. (Extrait du 66. Congrès des Sociétés savantes, 1933.)

Leick, Erich

Der Tau als Standortsfaktor. pp. 409-442. diags. 1934. (Reprint: Berichten der Deutsch. Botan. Gesellsch., Jahrg. 1933, Band 51, H. 10, ausgeg. 25. January 1934.)

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— and Senior, Mrs. F. A.

Does climate affect the human conception rate? Chicago. n. d. 9 p. charts. 25½ cm. (Repr.: Archives of internal medicine, December 1930, vol. 46, pp. 921-929.)

Patton, C. A.

Some observations on forty-six years of Ohio weather. Wooster. 1934. 32 p. ill., tab. 23 cm. (Ohio agric'l exper. station. Bull. 544. December 1934.)

Schmidt, Wilhelm

Kleinklimatische Beobachtungen in Österreich. Leipzig & Wien. 1933. pp. 42-72. maps and fold. map. 24 cm. (Geogr. Jahresber. aus Österreich, 16. Band.)

Neue Wege meteorologischer Forschung und ihre Bedeutung für Praxis und Leben. n. d. pp. 79-114. ill. 23 cm. (Sonderdruck aus "Deutsche Forschung.")

Weickmann, L.

Die meteorologischen Ergebnisse der Polarfahrt des "Graf Zeppelin" Juli 1931. Leipzig. 1932. pp. 333-346. tables, fold., and plates. 22½ cm. (Abdruck: Bericht. Math.-phys. Klasse, Sächs. Akad. der Wissensch. zu Leipzig. 84 Band, 2 Nov. 1931.)

## SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING  
JANUARY 1935

By IRVING F. HAND, Assistant in Solar Radiation Investigations

Measurements of the intensity of direct solar radiation at normal incidence are now made at Washington, D. C., Madison, Wis., and Lincoln, Nebr., by this Bureau; and by Harvard University, at Blue Hill, Mass. Summaries of all these observations are published regularly in the REVIEW.

At Washington the readings are made with a Marvin pyrheliometer for the most part, and with thermopiles and a Smithsonian silver-disk pyrheliometer for special

purposes; all instruments are located on the campus of the American University, about 3 miles northwest of the central office of the Weather Bureau, 5½ miles northwest of the United States Capitol and 1½ miles northwest of the Naval Observatory. There are no manufacturing plants within 3 miles of the university, but increased suburban development has gradually increased pollution of the atmosphere by smoke.

At Madison the pyrheliometric equipment is located in North Hall, University of Wisconsin, on a bluff a short distance from the south shore of Lake Mendota. Most of the manufacturing establishments are in the eastern part of the city, but some contamination results from the

university's heating plant and the railroad lines adjoining the campus.

At Lincoln the radiation apparatus is located on the farm campus of the State University, 2½ miles northeast of the business section of the city. With a west or northwest wind the atmosphere is very clear; but with other directions, smoke from railroads and industrial plants often depletes radiation receipt.

Marvin pyrhelimeters are used for normal incidence measurements at both Madison and Lincoln. These are checked at intervals with a Smithsonian silver-disk pyrhelimeter.

At Blue Hill the observatory is located on the highest point of a long ridge 10 miles south of Boston, and little trouble is experienced from smoke, although occasionally with a north wind a slight smoke-effect is felt from that city. A thermopile registering continuously on a potentiometer, and frequently checked with a Smithsonian silver-disk pyrhelimeter, is used for this type of measurement.

Continuous records of total radiation received from the sun and sky are regularly obtained at eight Weather Bureau stations, and at an equal number of cooperating

stations through the courtesy of the Bureau of Entomology (Twin Falls, Idaho), the Scripps Institution of Oceanography (La Jolla, Calif.), Dr. O. J. Sieplein (Miami, Fla.), and the universities of Tulane (New Orleans), California (Riverside), Harvard (Blue Hill and Mount Washington), and Washington (Friday Harbor).

Through the courtesy of Dr. A. J. Heinicke, of the New York State College of Agriculture, Cornell University, Ithaca, N. Y., records will soon be available from that city for regular inclusion in the REVIEW. This Bureau is now establishing a new pyrhelimetric station at San Juan, Puerto Rico; and records from this station should be available within a few weeks. The pyrhelimeter at Pittsburgh has recently been moved from the business section to the airport station in the suburbs of that city, and records from this new site should also begin within a few weeks.

For a description of the different types of radiation apparatus employed at these several stations the reader is referred to Weather Bureau Circular Q, Pyrhelimeters and Pyrhelimetric Measurements, Washington, 1931.

The coordinates of the different stations and the instruments employed are as follows:

| Stations                | Instruments   | Registers                    | Latitude, north | Longitude, west | Altitude | Under direction of—                  |
|-------------------------|---|------------------------------|-----------------|-----------------|----------|--------------------------------------|
| Washington, D. C.       | Marvin, Smithsonian, Eppler                         | Engelhard, and potentiometer | 38 56           | 77 05           | 397      | U. S. Weather Bureau.                |
| Madison, Wis.           | Marvin and Callendar                                | Callendar                    | 43 05           | 89 23           | 974      | Do.                                  |
| Lincoln, Nebr.          | do  | do                           | 40 50           | 96 41           | 1,009    | Do.                                  |
| Chicago, Ill.           | Eppler  | Engelhard                    | 41 47           | 87 35           | 1,225    | Do.                                  |
| New York, N. Y.         | do  | do                           | 40 46           | 73 58           | 1,250    | Do.                                  |
| Fresno, Calif.          | do  | do                           | 36 43           | 119 49          | 688      | Do.                                  |
| Pittsburgh, Pa.         | do  | do                           | 40 22           | 79 56           | 156      | Do.                                  |
| Fairbanks, Alaska       | do  | do                           | 64 52           | 147 39          | 330      | Do.                                  |
| Twin Falls, Idaho       | do  | do                           | 42 29           | 114 25          | 1,293    | Do.                                  |
| La Jolla, Calif.        | do  | do                           | 32 50           | 117 15          | 500      | U. S. Bureau of Entomology.          |
| Miami, Fla.             | Callendar <sup>1</sup>                              | Callendar                    | 25 41           | 80 12           | 85       | Scripps Institution of Oceanography. |
| New Orleans, La.        | Eppler  | Richard                      | 29 39           | 84 21           | 86       | Dr. O. J. Sieplein.                  |
| Riverside, Calif.       | do  | Engelhard                    | 33 58           | 117 28          | 233      | Tulane University.                   |
| Blue Hill, Mass.        | Eppler, and Eppler thermopile for normal incidence. | L. and N. potentiometer      | 42 13           | 71 07           | 1,051    | University of California.            |
| Mount Washington, N. H. | Eppler  | Engelhard                    | 44 16           | 71 18           | 640      | Harvard University.                  |
| Friday Harbor, Wash.    | do  | do                           | 48 32           | 123 01          | 6,270    | Do.                                  |
| San Juan, Puerto Rico   | Engelhard   | do                           | 18 28           | 16 06           | 15       | University of Washington.            |
| Ithaca, N. Y.           | Eppler  | L. and N. potentiometer      | 42 27           | 76 29           | 85       | U. S. Weather Bureau.                |
|                         |   |                              |                 |                 | 953      | Cornell University.                  |

<sup>1</sup> Records on Ångström scale of pyrhelimetry; all others on Smithsonian scale of pyrhelimetry.

Table 1 shows that solar radiation intensities averaged above normal for January at all three stations for which normals have been computed.

Table 2 shows an excess in the amount of total solar and sky radiation received on a horizontal surface at all stations except Madison, Lincoln, and Riverside.

Table 3 shows considerably less water-content of the atmosphere than did the turbidity measurements for the previous month.

Polarization measurements obtained on 4 days at Washington give a mean of 55 percent, with a maximum of 60 percent on the 2d. Both of these values are slightly below the January normals for Washington. No polarization readings were obtained at Madison during January because of continuous snow coverage.

**Correction.**—Corrected values of the total solar and sky radiation just received from Blue Hill Observatory give for the means of the weeks beginning December 3, 10, 17, and 24, 1934: 193, 181, 132, and 173, respectively.

TABLE 1.—Solar radiation intensities during January 1935  
[Gram-calories per minute per square centimeter of normal surface]

| WASHINGTON, D. C. |                       |          |       |       |       |       |       |       |        |       |       |                                |
|-------------------|-----------------------|----------|-------|-------|-------|-------|-------|-------|--------|-------|-------|--------------------------------|
| Date              | Sun's zenith distance |          |       |       |       |       |       |       |        |       |       |                                |
|                   | 8 a.m.                | 78.7°    | 75.7° | 70.7° | 60.0° | 0.0°  | 60.0° | 70.7° | 75.7°  | 78.7° | Noon  |                                |
|                   | 75th<br>mer.<br>time  | Air mass |       |       |       |       |       |       |        |       |       | Local<br>mean<br>solar<br>time |
|                   |                       | A. M.    |       |       |       |       | P. M. |       |        |       |       |                                |
|                   |                       | e        | 5.0   | 4.0   | 3.0   | 2.0   | *1.0  | 2.0   | 3.0    | 4.0   | 5.0   |                                |
| Jan. 2.....       | mm.                   | cal.     | cal.  | cal.  | cal.  | cal.  | cal.  | cal.  | cal.   | cal.  | mm.   |                                |
| Jan. 3.....       | 1.45                  | 0.87     | 1.04  | 1.18  | 1.45  | ----- | ----- | 1.16  | 1.12   | 0.98  | 1.96  |                                |
| Jan. 4.....       | 2.87                  | 1.01     | 1.14  | 1.27  | 1.43  | ----- | ----- | ----- | -----  | ----- | 2.74  |                                |
| Jan. 5.....       | 1.45                  | .87      | 1.14  | 1.20  | 1.45  | ----- | ----- | 1.24  | 1.09   | .92   | 1.45  |                                |
| Jan. 5.....       | 2.06                  | .47      | .09   | 1.01  | 1.14  | ----- | ----- | ----- | -----  | ----- | 3.00  |                                |
| Jan. 12.....      | 2.49                  | -----    | .62   | ----- | ----- | ----- | ----- | ----- | -----  | ----- | 2.49  |                                |
| Jan. 24.....      | .81                   | 1.07     | 1.19  | 1.30  | 1.47  | ----- | ----- | 1.12  | -----  | ----- | 1.02  |                                |
| Means.....        | -----                 | .86      | .97   | 1.19  | 1.29  | ----- | ----- | 1.17  | (1.10) | (.95) | ----- |                                |
| Departures.....   | -----                 | + .12    | + .11 | + .17 | + .15 | ----- | ----- | + .12 | + .21  | + .14 | ----- |                                |

\* Extrapolated.

TABLE 1.—Solar radiation intensities during January 1935—Contd.  
[Gram-calories per minute per square centimeter of normal surface]

## MADISON, WIS.

| Date            | Sun's zenith distance |          |        |       |       |      |       |       |        |       |      | Local mean solar time |
|-----------------|-----------------------|----------|--------|-------|-------|------|-------|-------|--------|-------|------|-----------------------|
|                 | 8 a. m.               | 78.7°    | 75.7°  | 70.7° | 60.0° | 0.0° | 60.0° | 70.7° | 75.7°  | 78.7° | Noon |                       |
|                 | 75th mer. time        | Air mass |        |       |       |      |       |       |        |       |      |                       |
|                 |                       | A. M.    |        |       |       |      |       | P. M. |        |       |      |                       |
|                 |                       | e        | 5.0    | 4.0   | 3.0   | 2.0  | *1.0  | 2.0   | 3.0    | 4.0   | 5.0  |                       |
| Jan. 3.....     | mm.                   | 2.49     |        |       |       |      |       | 1.37  |        |       | 1.24 |                       |
| Jan. 14.....    |                       | .58      | 1.07   |       |       |      |       |       |        |       | .79  |                       |
| Jan. 17.....    |                       | 2.26     |        |       | 1.20  | 1.44 |       | 1.28  | 1.17   |       | 1.68 |                       |
| Jan. 22.....    |                       | .51      |        |       | .97   | 1.23 |       |       |        |       | .86  |                       |
| Jan. 23.....    |                       | .23      | 1.11   | 1.22  | 1.36  | 1.52 |       | 1.41  |        |       | .28  |                       |
| Jan. 29.....    |                       | 1.96     |        |       | 1.22  | 1.32 |       |       |        |       | 1.78 |                       |
| Means.....      |                       | (1.09)   | (1.20) | 1.22  | 1.38  |      |       | 1.35  | (1.17) |       |      |                       |
| Departures..... |                       | +.13     | +.14   | +.01  | +.03  |      |       | +.20  | +.10   |       |      |                       |

## LINCOLN, NEBR.

|                 |      |      |      |        |      |  |  |      |      |      |      |
|-----------------|------|------|------|--------|------|--|--|------|------|------|------|
| Jan. 2.....     | 2.49 | .92  | 1.10 | 1.24   |      |  |  | 1.17 | 1.02 | .82  | 2.16 |
| Jan. 3.....     | 1.24 | .73  | .96  | 1.15   |      |  |  | 1.33 | 1.19 | 1.06 | .81  |
| Jan. 4.....     | 1.37 | .97  | 1.07 | 1.19   |      |  |  | 1.18 | 1.01 | .87  | 1.88 |
| Jan. 10.....    | 4.17 | .93  | 1.22 |        |      |  |  | 1.32 | 1.19 | 1.05 | 4.75 |
| Jan. 21.....    | .38  |      |      | 1.40   |      |  |  | 1.27 | 1.12 | .94  | .71  |
| Jan. 25.....    | 2.62 |      |      |        | 1.25 |  |  | 1.06 | .97  | 4.57 |      |
| Means.....      | .87  | .99  | 1.24 | (1.25) |      |  |  | 1.25 | 1.10 | .95  |      |
| Departures..... | -.05 | -.05 | +.06 | -.12   |      |  |  | +.08 | +.05 | +.02 |      |

TABLE 1.—Solar radiation intensities during January 1935—Contd.

## BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

| Date          | Sun's zenith distance |           |       |       |       |      |       |       |       |       |         | Local mean solar time |
|---------------|-----------------------|-----------|-------|-------|-------|------|-------|-------|-------|-------|---------|-----------------------|
|               | 8 a. m.               | 78.7°     | 75.7° | 70.7° | 60.0° | 0.0° | 60.7° | 70.7° | 75.0° | 78.7° | Noon    |                       |
|               | 75th mer. time        | Air mass  |       |       |       |      |       |       |       |       |         |                       |
|               |                       | A. M.     |       |       |       |      | P. M. |       |       |       |         |                       |
|               |                       | e         | 5.0   | 4.0   | 3.0   | 2.0  | *1.0  | 2.0   | 3.0   | 4.0   | 5.0     |                       |
| Jan. 2.-----  | mm. 1.3               | cal. 1.00 | 1.10  | 1.28  | 1.49  |      | 1.49  | 1.36  |       |       | mm. 0.7 |                       |
| Jan. 3.-----  | 2.6                   |           |       | .89   | 1.05  |      | 1.07  | .98   |       |       | 2.8     |                       |
| Jan. 4.-----  | .8                    | 1.03      | 1.18  | 1.33  | 1.45  |      | 1.45  | 1.33  | 1.21  | 1.10  | .5      |                       |
| Jan. 5.-----  | .7                    | 1.05      | 1.12  | 1.20  | 1.29  |      | 1.29  |       |       |       | 1.6     |                       |
| Jan. 11.----- | 3.5                   | .56       | .82   | 1.13  | 1.34  |      | 1.34  |       |       |       | 2.1     |                       |
| Jan. 12.----- | 1.8                   | .97       | 1.08  | 1.22  | 1.40  |      | 1.40  | 1.35  |       |       | 1.2     |                       |
| Jan. 15.----- | .9                    |           | 1.13  | 1.26  | 1.41  |      | 1.41  | 1.24  | 1.13  |       | .7      |                       |
| Jan. 16.----- | 1.5                   |           | .80   | 1.00  | 1.28  |      | 1.28  | 1.18  | 1.14  |       | 1.2     |                       |
| Jan. 18.----- | 2.6                   |           | 1.01  | 1.17  | 1.35  |      | 1.36  | 1.18  | 1.02  |       | 1.5     |                       |
| Jan. 19.----- |                       |           | 1.02  | 1.17  | 1.36  |      |       |       |       |       |         |                       |
| Jan. 24.----- | 1.6                   |           |       |       |       |      | 1.34  | 1.20  |       |       | 1.3     |                       |
| Jan. 25.----- | .4                    |           |       | 1.23  | 1.42  |      | 1.42  | 1.29  |       |       | .5      |                       |
| Jan. 26.----- | 2.0                   |           |       | .82   | .99   |      |       |       |       |       | 1.8     |                       |
| Jan. 27.----- | .6                    |           | 1.18  | 1.36  | 1.43  |      | 1.43  | 1.36  | 1.26  |       | .6      |                       |
| Jan. 28.----- | .7                    |           |       | 1.23  | 1.40  |      |       |       |       |       | .6      |                       |
| Jan. 30.----- | .7                    |           |       | 1.22  | 1.48  |      | 1.47  | 1.36  | 1.27  |       | .6      |                       |
| Jan. 31.----- | .7                    |           |       | 1.22  | 1.44  |      | 1.44  | 1.28  |       |       | .6      |                       |
| Means-----    |                       | .92       | 1.04  | 1.10  | 1.35  |      | 1.37  | 1.24  | 1.17  | 1.10  |         |                       |

TABLE 2.—Average daily totals of solar radiation (direct + diffuse) received on a horizontal surface

| Week beginning—                   | Gram calories per square centimeter |         |         |         |          |        |           |            |       |             |            |           |               |
|-----------------------------------|-------------------------------------|---------|---------|---------|----------|--------|-----------|------------|-------|-------------|------------|-----------|---------------|
|                                   | Washington                          | Madison | Lincoln | Chicago | New York | Fresno | Fairbanks | Twin Falls | Miami | New Orleans | River-side | Blue Hill | Friday Harbor |
| 1935                              | cal.                                | cal.    | cal.    | cal.    | cal.     | cal.   | cal.      | cal.       | cal.  | cal.        | cal.       | cal.      | cal.          |
| January 1.....                    | 234                                 | 150     | 217     | 128     | 189      | 143    | 15        |            | 273   | 182         | 212        | 207       | 63            |
| January 8.....                    | 186                                 | 87      | 164     | 66      | 117      | 169    | 7         |            | 339   | 251         | 158        | 142       | 97            |
| January 15.....                   | 145                                 | 117     | 159     | 83      | 111      | 237    | 33        |            | 278   | 164         | 295        | 174       | 90            |
| January 22.....                   | 192                                 | 186     | 224     | 134     | 155      | 225    | 46        |            | 368   | 263         | 282        | 221       | 52            |
| Departures from weekly normals    |                                     |         |         |         |          |        |           |            |       |             |            |           |               |
| January 1.....                    | +80                                 | +20     | +36     | +45     | +33      | 0      | +8        |            | -19   | +19         | -14        |           |               |
| January 8.....                    | +33                                 | -49     | -21     | -14     | +8       | +17    | -2        |            | +49   | +64         | -90        |           |               |
| January 15.....                   | -19                                 | -39     | -36     | -17     | -1       | +57    | +18       |            | -16   | -30         | +12        |           |               |
| January 22.....                   | +15                                 | +3      | -2      | +17     | +9       | +14    | +23       |            | +44   | +71         | -13        |           |               |
| Accumulated departures on Jan. 28 |                                     |         |         |         |          |        |           |            |       |             |            |           |               |
|                                   | +763                                | -455    | -161    | +217    | +343     | +616   | +320      |            | +406  | +868        | -735       |           |               |

TABLE 3.—Total,  $I_m$ , and screened,  $I_v$ ,  $I_r$ , solar radiation intensity measurements, obtained during January 1935, and determinations of the atmospheric turbidity factor,  $\beta$ , and water-vapor content,  $w$ =depth in millimeters, if precipitated

AMERICAN UNIVERSITY, WASHINGTON, D. C.

| Date and hour angle | Solar altitude | Air mass | $I_m$          | $I_v$          | $I_r$          | $\beta_{I_m-r}$ | $\beta_{I_v-r}$ | $\beta_{mean}$ | $\frac{I_{w=0}}{1.94}$       | $\frac{I_{w=0}I_m}{1.94}$ | $w$ | Air-mass type   |
|---------------------|----------------|----------|----------------|----------------|----------------|-----------------|-----------------|----------------|------------------------------|---------------------------|-----|-----------------|
|                     |                |          |                |                |                |                 |                 |                | Percentage of solar constant |                           |     |                 |
|                     |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| Jan. 2, 1935        |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| 2:34 a. m.          | 18 24          | 3.14     | gr. cal. 1.132 | gr. cal. 0.908 | gr. cal. 0.726 | 0.072           | 0.022           | 0.047          | 65.0                         | 8.6                       | 2.6 | P <sub>C</sub>  |
| 1:57 a. m.          | 22 22          | 2.61     | 1.297          | .956           | .769           | .042            | .028            | .035           | 72.8                         | 8.2                       | 2.6 |                 |
| 1:53 a. m.          | 22 42          | 2.58     | 1.317          | .957           | .770           | .036            | .030            | .033           | 73.7                         | 8.0                       | 2.6 |                 |
| Jan. 3, 1935        |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| 3:09 a. m.          | 14 02          | 4.10     | 1.153          | .871           | .715           | .032            | .026            | .029           | 65.3                         | 7.7                       | 1.3 | N <sub>PP</sub> |
| 3:04 a. m.          | 14 42          | 3.82     | 1.160          | .872           | .717           | .018            | .022            | .020           | 69.5                         | 9.0                       | 2.4 |                 |
| 2:46 a. m.          | 17 02          | 3.39     | 1.242          | .922           | .738           | .025            | .018            | .022           | 71.8                         | 9.9                       | 4.2 |                 |
| 2:38 a. m.          | 18 02          | 3.20     | 1.240          | .941           | .750           | .036            | .018            | .027           | 70.1                         | 8.3                       | 2.2 |                 |
| 2:34 a. m.          | 18 30          | 3.13     | 1.261          | .946           | .753           | .032            | .014            | .024           | 72.2                         | 9.5                       | 3.8 |                 |
| Jan. 4, 1935        |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| 3:13 a. m.          | 13 33          | 4.22     | 1.100          | .839           | .689           | .038            | .028            | .033           | 62.8                         | 8.0                       | 1.4 | P <sub>C</sub>  |
| 3:09 a. m.          | 14 06          | 4.06     | 1.136          | .842           | .692           | .028            | .022            | .025           | 66.0                         | 9.4                       | 2.8 |                 |
| 1:54 a. m.          | 22 47          | 2.58     | 1.320          | .935           | .741           | .038            | .018            | .028           | 74.0                         | 8.2                       | 2.6 |                 |
| 0:57 a. m.          | 26 54          | 2.22     | 1.350          | .932           | .759           | .036            | .056            | .046           | 73.7                         | 6.3                       | 1.4 |                 |
| 0:52 a. m.          | 27 08          | 2.19     | 1.353          | .935           | .759           | .035            | .055            | .045           | 73.7                         | 6.2                       | 1.3 |                 |
| Jan. 5, 1935        |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| 3:18 a. m.          | 12 58          | 4.40     | .579           | .491           | .414           | .150            | .110            | .130           | 40.0                         | 11.5                      | 6.5 | N <sub>PP</sub> |
| 3:14 a. m.          | 13 30          | 4.25     | .610           | .495           | .419           | .140            | .120            | .130           | 40.6                         | 10.2                      | 3.7 |                 |
| 3:07 a. m.          | 14 28          | 3.96     | .705           | .556           | .488           | .090            | .130            | .110           | 41.0                         | 8.9                       | 2.3 |                 |
| 3:03 a. m.          | 15 00          | 3.82     | .688           | .556           | .488           | .110            | .140            | .125           | 43.4                         | 9.1                       | 2.6 |                 |
| 2:50 a. m.          | 16 45          | 3.45     | .968           | .687           | .579           | .065            | .097            | .081           | 54.8                         | 6.5                       | 0.9 |                 |
| Jan. 24, 1935       |                |          |                |                |                |                 |                 |                |                              |                           |     |                 |
| 1:09 a. m.          | 29 34          | 2.02     | 1.445          | 1.020          | .802           | .025            | .014            | .020           | 80.0                         | 7.9                       | 2.9 | P <sub>C</sub>  |
| 1:06 a. m.          | 29 46          | 2.01     | 1.458          | 1.020          | .802           | .027            | .014            | .020           | 80.2                         | 8.3                       | 3.5 |                 |

## Atmospheric conditions during turbidity measurements

Jan. 2: Temperature, -2°C; wind, NW. 12; polarization, 60 percent; blueness of sky, 6.

Jan. 3: Temperature, 3°C; wind, NW. 10; polarization, 58 percent; blueness of sky, 5.

Jan. 4: Temperature, 0°C; wind, NW. 8; polarization, 56 percent; blueness of sky, 5.

Jan. 5: Temperature, -1°C; wind, SE. 4.

Jan. 24: Temperature, -8°C; wind, NW. 12.

## BLUE HILL OBSERVATORY OF HARVARD UNIVERSITY

| Date and hour angle | Solar altitude | Air mass | $I_m$ | $I_v$ | $I_r$ | $\beta_{I_m-r}$ | $\beta_{I_v-r}$ | $\beta_{mean}$ | $\frac{I_{w=0}}{1.94}$       | $\frac{I_{w=0}I_m}{1.94}$ | $w$ | Air-mass type   |  |
|---------------------|----------------|----------|-------|-------|-------|-----------------|-----------------|----------------|------------------------------|---------------------------|-----|-----------------|--|
|                     |                |          |       |       |       |                 |                 |                | Percentage of solar constant |                           |     |                 |  |
|                     |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| Jan. 2, 1935        |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 2:46 a. m.          | 14 24          | 3.97     | 1.105 | 0.870 | 0.748 | 0.057           | 0.073           | 0.065          | 62.8                         | 7.7                       | 3.4 | Pc, NPr aloft.  |  |
| 2:24 a. m.          | 16 50          | 3.43     | 1.191 | .916  | .766  | .044            | .043            | .044           | 64.4                         | 5.0                       | 3.6 |                 |  |
| 1:09 a. m.          | 22 54          | 2.56     | 1.352 | 1.012 | .838  | .043            | .040            | .042           | 71.1                         | 3.7                       | 4.5 |                 |  |
| 0:48 a. m.          | 23 53          | 2.46     | 1.381 | 1.029 | .843  | .038            | .034            | .036           | 73.2                         | 4.4                       | 4.4 | Pc              |  |
| 0:08 a. m.          | 24 48          | 2.37     | 1.396 | 1.032 | .843  | .036            | .033            | .034           | 74.7                         | 5.1                       | 5.2 |                 |  |
| 0:20 p. m.          | 24 39          | 2.39     | 1.401 | 1.034 | .848  | .035            | .036            | .036           | 74.0                         | 4.2                       | 4.9 |                 |  |
| 1:22 p. m.          | 22 07          | 2.64     | 1.362 | 1.009 | .831  | .032            | .049            | .040           | 71.0                         | 3.1                       | 4.1 | NPr, NPr aloft. |  |
| Jan. 3, 1935        |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 0:52 a. m.          | 23 43          | 2.48     | .938  | .682  | .567  | .097            | .142            | .120           | 55.6                         | 8.8                       | 5.5 |                 |  |
| 0:30 a. m.          | 24 27          | 2.41     | .972  | .711  | .594  | .094            | .143            | .118           | 57.0                         | 8.5                       | 5.6 | Pc              |  |
| 0:24 p. m.          | 24 35          | 2.39     | 1.032 | .757  | .633  | .094            | .123            | .108           | 59.2                         | 7.8                       | 5.6 |                 |  |
| 1:59 p. m.          | 19 16          | 3.00     | .976  | .717  | .590  | .067            | .091            | .079           | 69.2                         | 4.8                       | 4.1 |                 |  |
| Jan. 4, 1935        |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 2:31 a. m.          | 16 18          | 3.53     | 1.259 | .964  | .816  | .038            | .047            | .042           | 64.5                         | 1.3                       | 2.5 | Pc              |  |
| 2:00 a. m.          | 19 23          | 2.99     | 1.336 | 1.006 | .852  | .040            | .053            | .046           | 67.9                         | 1.3                       | 3.0 |                 |  |
| 0:57 a. m.          | 23 42          | 2.48     | 1.390 | 1.023 | .852  | .035            | .050            | .042           | 71.2                         | 1.9                       | 3.9 |                 |  |
| 0:19 a. m.          | 24 52          | 2.36     | 1.428 | 1.042 | .866  | .033            | .050            | .042           | 72.7                         | 1.5                       | 3.9 | Pc              |  |
| 2:01 p. m.          | 19 28          | 2.98     | 1.334 | .994  | .818  | .026            | .034            | .030           | 72.5                         | 6.0                       | 4.3 |                 |  |
| Jan. 5, 1935        |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 0:25 a. m.          | 24 52          | 2.36     | 1.261 | .923  | .757  | .050            | .061            | .056           | 69.5                         | 5.9                       | 5.4 | Pc, NPr aloft.  |  |
| 1:29 p. m.          | 24 44          | 2.38     | 1.238 | .914  | .747  | .056            | .070            | .063           | 68.5                         | 4.8                       | 5.1 |                 |  |
| Jan. 11, 1935       |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 2:44 a. m.          | 15 35          | 3.68     | .905  | .707  | .614  | .090            | .110            | .100           | 49.0                         | 3.9                       | 3.2 | NPr             |  |
| 2:24 a. m.          | 17 45          | 3.26     | 1.061 | .829  | .697  | .074            | .070            | .072           | 58.6                         | 5.7                       | 3.9 |                 |  |
| 0:40 a. m.          | 25 16          | 2.33     | 1.281 | .949  | .768  | .049            | .042            | .046           | 71.0                         | 6.2                       | 5.5 |                 |  |
| 0:21 a. m.          | 25 44          | 2.30     | 1.291 | .954  | .773  | .048            | .043            | .046           | 72.2                         | 7.9                       | 5.9 | Pc & NPr        |  |
| 1:33 p. m.          | 22 25          | 2.61     | 1.290 | .945  | .772  | .035            | .047            | .041           | 70.9                         | 6.6                       | 5.0 |                 |  |
| Jan. 12, 1935       |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 2:19 a. m.          | 18 28          | 3.13     | 1.202 | .912  | .760  | .047            | .052            | .050           | 64.5                         | 5.5                       | 4.0 | Pc              |  |
| 1:46 p. m.          | 21 32          | 2.71     | 1.392 | 1.014 | .833  | .019            | .031            | .025           | 74.7                         | 5.3                       | 4.6 |                 |  |
| 2:13 p. m.          | 19 04          | 3.03     | 1.348 | 1.000 | .823  | .022            | .027            | .024           | 72.3                         | 5.5                       | 4.1 |                 |  |
| Jan. 15, 1935       |                |          |       |       |       |                 |                 |                |                              |                           |     |                 |  |
| 2:32 a. m.          | 17 32          | 3.30     | 1.225 | .937  | .791  | .044            | .054            | .049           | 63.1                         | 1.9                       | 3.0 | Pc              |  |
| 1:02 a. m.          | 25 23          | 2.33     | 1.365 | 1.015 | .837  | .047            | .048            | .048           | 71.5                         | 3.4                       | 4.8 |                 |  |
| 1:58 p. m.          | 21 00          | 2.77     | 1.274 | .941  | .794  | .046            | .068            | .057           | 66.5                         | 2.7                       | 3.9 |                 |  |
| 2:08 p. m.          | 20 02          | 2.90     | 1.260 | .940  | .778  | .039            | .048            | .044           | 67.3                         | 4.5                       | 4.1 | NPr aloft       |  |

TABLE 3.—Total,  $I_m$ , and screened,  $I_y$ ,  $I_r$ , solar radiation intensity measurements, obtained during January 1935, and determinations of the atmospheric turbidity factor,  $\beta$ , and water-vapor content,  $w$ =depth in millimeters, if precipitated—Continued

BLUE HILL OBSERVATORY OF HARVARD UNIVERSITY—Continued

| Date and hour angle | Solar altitude | Air mass | $I_m$ | $I_y$ | $I_r$ | $\beta_{I_m-r}$ | $\beta_{I_y-r}$ | $\beta_{m-r}$ | $\frac{I_m-r}{1.94}$         | $\frac{I_y-r}{1.94}$ | $w$ | Air-mass type             |
|---------------------|----------------|----------|-------|-------|-------|-----------------|-----------------|---------------|------------------------------|----------------------|-----|---------------------------|
|                     |                |          |       |       |       |                 |                 |               | Percentage of solar constant |                      |     |                           |
|                     |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| Jan. 16, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:57 a. m.          | 14 44          | 3.89     | 0.813 | 0.664 | 0.588 | 0.125           | 0.121           | 0.123         | 43.1                         | 2.6                  | 2.7 | Pc                        |
| 2:38 a. m.          | 17 01          | 3.39     | .870  | .688  | .607  | .125            | .145            | .135          | 44.8                         | 1.4                  | 2.7 |                           |
| 0:07 p. m.          | 26 45          | 2.22     | 1.213 | .904  | .755  | .081            | .093            | .087          | 65.0                         | 4.5                  | 5.4 |                           |
| 0:27 p. m.          | 26 28          | 2.24     | 1.229 | .923  | .769  | .079            | .081            | .080          | 65.7                         | 4.4                  | 5.3 | NPC-Pc                    |
| 2:08 p. m.          | 20 12          | 2.88     | 1.215 | .916  | .757  | .048            | .050            | .049          | 66.8                         | 5.2                  | 4.3 |                           |
| 2:25 p. m.          | 18 28          | 3.13     | 1.200 | .906  | .752  | .044            | .050            | .047          | 65.5                         | 5.6                  | 4.0 |                           |
| Jan. 18, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 0:58 p. m.          | 25 46          | 2.29     | 1.300 | .941  | .767  | .046            | .063            | .050          | 71.3                         | 6.5                  | 5.7 | NPC, T <sub>A</sub> aloft |
| 2:30 p. m.          | 18 17          | 3.16     | 1.134 | .866  | .706  | .045            | .043            | .044          | 66.1                         | 9.5                  | 4.4 |                           |
| Jan. 19, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:37 a. m.          | 17 40          | 3.26     | 1.125 | .864  | .732  | .062            | .071            | .066          | 60.1                         | 4.0                  | 3.6 |                           |
| 0:38 a. m.          | 26 45          | 2.22     | 1.318 | .976  | .781  | .024            | .027            | .026          | 71.8                         | 6.0                  | 5.7 |                           |
| 0:02 p. m.          | 27 22          | 2.17     | 1.244 | .908  | .761  | .044            | .078            | .061          | 70.0                         | 7.9                  | 6.2 |                           |
| Jan. 24, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 0:59 p. m.          | 27 00          | 2.20     | 1.314 | .946  | .764  | .038            | .045            | .042          | 74.0                         | 8.4                  | 6.1 | Pc, T <sub>A</sub> aloft  |
| 1:20 p. m.          | 25 46          | 2.29     | 1.307 | .941  | .764  | .033            | .049            | .041          | 73.6                         | 8.3                  | 5.9 |                           |
| 2:11 p. m.          | 21 28          | 2.71     | 1.244 | .917  | .745  | .037            | .041            | .039          | 70.9                         | 8.8                  | 5.0 |                           |
| Jan. 25, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 1:34 a. m.          | 25 00          | 2.36     | 1.320 | .964  | .790  | .041            | .050            | .046          | 69.6                         | 3.7                  | 4.9 | Pc                        |
| 0:16 p. m.          | 28 36          | 2.08     | 1.403 | 1.007 | .831  | .039            | .047            | .043          | 74.8                         | 4.7                  | 5.9 |                           |
| 0:39 p. m.          | 28 04          | 2.12     | 1.408 | 1.007 | .831  | .035            | .045            | .040          | 75.2                         | 4.9                  | 5.8 |                           |
| 2:06 p. m.          | 22 10          | 2.63     | 1.340 | .929  | .768  | .014            | .038            | .036          | 71.1                         | 5.1                  | 4.7 | Pc, NTP aloft             |
| Jan. 26, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:35 a. m.          | 19 24          | 2.99     | .817  | .629  | .544  | .168            | .160            | .164          | 43.7                         | 2.9                  | 3.6 | Pc, NTP aloft             |
| 1:11 a. m.          | 26 49          | 2.21     | .866  | .666  | .564  | .170            | .184            | .177          | 49.5                         | 6.7                  | 5.9 |                           |
| 0:25 a. m.          | 28 44          | 2.08     | .950  | .708  | .609  | .157            | .196            | .176          | 52.3                         | 4.9                  | 5.9 |                           |
| 0:05 p. m.          | 28 58          | 2.00     | .988  | .742  | .621  | .149            | .158            | .154          | 56.2                         | 6.9                  | 6.6 |                           |
| 0:35 p. m.          | 28 26          | 2.10     | .955  | .703  | .604  | .143            | .194            | .168          | 53.1                         | 5.4                  | 5.9 | Pc, NPC aloft             |
| Jan. 27, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 0:22 a. m.          | 29 00          | 2.06     | 1.424 | 1.023 | .849  | .040            | .056            | .048          | 72.7                         | 1.5                  | 4.5 | Pc                        |
| 0:45 p. m.          | 28 21          | 2.10     | 1.424 | 1.023 | .849  | .037            | .062            | .050          | 73.0                         | 1.8                  | 4.1 |                           |
| 1:06 p. m.          | 27 16          | 2.17     | 1.412 | 1.018 | .839  | .035            | .052            | .044          | 74.1                         | 3.5                  | 5.2 |                           |
| 2:36 p. m.          | 19 21          | 3.00     | 1.363 | 1.013 | .845  | .026            | .039            | .032          | 71.4                         | 3.3                  | 3.7 | Pc                        |
| Jan. 28, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:34 a. m.          | 19 50          | 2.93     | 1.229 | .925  | .776  | .049            | .061            | .055          | 64.8                         | 3.4                  | 3.8 | Pc                        |
| 2:15 a. m.          | 21 57          | 2.66     | 1.275 | .945  | .781  | .043            | .050            | .046          | 66.9                         | 3.1                  | 4.1 |                           |
| 0:21 a. m.          | 29 18          | 2.04     | 1.369 | .978  | .795  | .038            | .050            | .044          | 72.2                         | 3.7                  | 5.5 | Pc, NTP aloft             |
| Jan. 30, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:12 a. m.          | 22 46          | 2.57     | 1.304 | .976  | .818  | .070            | .061            | .066          | 65.5                         | .2                   | .1  | Pc                        |
| 0:13 p. m.          | 29 57          | 2.00     | 1.476 | 1.049 | .867  | .030            | .054            | .042          | 75.8                         | 1.9                  | 1.5 |                           |
| 0:33 p. m.          | 29 32          | 2.02     | 1.471 | 1.049 | .860  | .026            | .044            | .035          | 78.3                         | 4.2                  | 2.1 |                           |
| 2:04 p. m.          | 23 33          | 2.50     | 1.387 | 1.009 | .811  | .024            | .018            | .021          | 77.1                         | 7.5                  | 3.1 | Pc                        |
| Jan. 31, 1935       |                |          |       |       |       |                 |                 |               |                              |                      |     |                           |
| 2:03 a. m.          | 23 52          | 2.46     | 1.360 | .966  | .817  | .030            | .048            | .039          | 72.6                         | 4.5                  | 2.7 | Pc                        |
| 0:28 a. m.          | 29 56          | 2.00     | 1.444 | 1.036 | .837  | .027            | .030            | .028          | 79.0                         | 6.7                  | 3.7 |                           |
| 0:07 p. m.          | 30 16          | 1.98     | 1.429 | 1.036 | .830  | .032            | .021            | .026          | 79.7                         | 8.2                  | 4.0 |                           |
| 0:30 p. m.          | 29 53          | 2.00     | 1.444 | 1.031 | .830  | .0225           | .027            | .026          | 79.6                         | 7.3                  | 3.8 |                           |
| 2:06 p. m.          | 23 36          | 2.49     | 1.375 | .924  | .818  | .029            | .050            | .029          | 75.0                         | 6.2                  | 3.0 |                           |
| 2:44 p. m.          | 19 20          | 3.00     | 1.275 | .924  | .768  | .025            | .050            | .038          | 69.3                         | 5.5                  | 2.3 | Pc                        |

Atmospheric conditions during solar radiation measurements, Blue Hill Observatory of Harvard University

## POSITIONS AND AREAS OF SUN SPOTS—Continued

| Date and time from apparent noon | Air temperature | Wind (Beaufort Scale) | Visibility (scale 0-10) | Sky blue-ness | Cloudiness and remarks                                     |
|----------------------------------|-----------------|-----------------------|-------------------------|---------------|--|
| <b>January 1935</b>              |                 |                       |                         |               |  |
| 2:24 a. m.                       | -10.0           | W 6                   | 7-9                     | 5             | 1 Stcu, few Cu, light haze.                                |
| 2:105 a. m.                      | -8.3            | W 7                   | 8                       | 5             | Few Acu, few Cu, light haze.                               |
| 2:030 a. m.                      | -6.7            | W 7                   | 8                       | 5             | Few Acu, light haze.                                       |
| 2:247 p. m.                      | -5.6            | WNW 6                 | 9                       | 5             | Few Cist, few Acu, few Cu.                                 |
| 3:058 a. m.                      | +2.5            | S 5                   | 7                       | 5             | 4 Ci, mod. water haze.                                     |
| 3:139 p. m.                      | +5.7            | SW 5                  | 8                       | 4             | Few Cist, mod. water haze.                                 |
| 4:219 a. m.                      | -15.6           | NW 7                  | 9                       | 10            | Few Frcu, light haze. Blue sky obs. hereafter made in sun. |
| 4:037 a. m.                      | -14.9           | NW 7                  | 9                       | 10            | Few Cist, few Frcu.  |
| 4:205 p. m.                      | -13.3           | W 5                   | 9                       | 12            | Few Cist, few Frcu, light haze.                            |
| 4:325 p. m.                      | -12.2           | WNW 3                 | 9                       | 12            | Few Cist.  |
| 5:106 p. m.                      | -3.5            | S 4                   | 8                       | 12            | 7 Cist, few Cu. Prob. Cist over sun.                       |
| 11:249 a. m.                     | 0.0             | W 5                   | 7                       | 8             | Few Acu, mod. water haze.                                  |
| 11:035 a. m.                     | +2.2            | W 6                   | 9                       | 9             | 1 Ci, 1 Cu, Frcu.  |
| 11:139 p. m.                     | +2.8            | W 7                   | 9                       | 8             | 2 Cicu, 4 Cu, Frcu.  |
| 12:237 a. m.                     | -6.7            | NW 4                  | 8                       | 9             | Few Frcu in E, few Stcu, Cu in W.                          |
| 12:155 p. m.                     | -5.6            | NW 8                  | 9                       | 9             | 1 Stcu, Cu.  |
| 15:238 a. m.                     | -15.0           | NW 5                  | 7                       | 9             | Few Cist, Cicu.  |
| 15:053 a. m.                     | -13.3           | NW 5                  | 8                       | 10            | 3 Ci, Cist, increasing.                                    |
| 15:155 p. m.                     | -9.4            | WNW 5                 | 9                       | 11            | Ci haze, 4 Acu.  |
| 16:243 a. m.                     | -13.3           | N 5                   | 6                       | 8             | 2 Acu, thick haze.   |
| 16:123 a. m.                     | -11.1           | N 5                   | 6                       | 9             | No clouds, thick haze.                                     |
| 16:011 p. m.                     | -8.9            | NW 4                  | 6                       | 9             | Do.  |
| 16:211 p. m.                     | -7.2            | NW 3                  | 7                       | 10            | Few Cu, thick haze.  |
| 18:034 p. m.                     | -2.2            | NW 6                  | 9                       | 10            | 4 Cu, Stcu.  |
| 18:221 p. m.                     | -7.2            | NW 5                  | 9                       | 12            | Few Cu, Frcu.  |
| 24:101 p. m.                     | -11.7           | NNW 6                 | 8-9                     | 4             | 1 Ci, Few Cu.  |
| 24:217 p. m.                     | -11.7           | NW 6                  | 9                       | 5             | 2 Ci, Acu, Stcu.   |
| 24:359 p. m.                     | -12.8           | NW 6                  | 9                       | 5             | 3 Ci, Acu, Stcu.   |
| 25:228 a. m.                     | -20.6           | WNW 5                 | 9                       | 10            | 1 Ci, Cist, light haze.                                    |
| 25:150 a. m.                     | -19.4           | WNW 5                 | 9                       | 10            | 3 Ci, Cist, light haze.                                    |
| 25:022 p. m.                     | -16.1           | WNW 5                 | 9                       | 10            | 2 Cist, Ci, light haze.                                    |
| 26:128 a. m.                     | -8.3            | SW 4                  | 6                       | 7             | 4 Acu, thick water haze.                                   |
| 26:013 a. m.                     | -6.1            | SW 4                  | 6                       | 8             | 2 Acu, thick water haze.                                   |
| 27:217 a. m.                     | -20.8           | NW 5                  | 8-9                     | 9             | 1 Acu, light haze.   |
| 27:048 p. m.                     | -17.8           | NW 5                  | 9                       | 11            | Do.  |
| 27:211 p. m.                     | -16.2           | NW 4                  | 9                       | 11            | 1 Acu, no haze.  |
| 28:230 a. m.                     | -20.2           | N 3                   | 7-9                     | 2             | 2 Acu, Cicu.   |
| 28:349 p. m.                     | -5.6            | WNW 3                 | 6                       | 7             | 4 Acu, heavy haze.   |
| 30:230 a. m.                     | -18.9           | NW 5                  | 8                       | 10            | Few Ci.  |
| 30:014 p. m.                     | -14.9           | NW 5                  | 8                       | 5             | Do.  |
| 30:208 p. m.                     | -12.9           | NW 4                  | 8                       | 5             | Do.  |
| 31:211 a. m.                     | -10.6           | NWxN 4                | 7-8                     | 11            | Few Acu, few Frcu, mod. haze inversion.                    |
| 31:012 p. m.                     | -15.6           | NW 4                  | 8                       | 11            | Haze like Ci fum over sun, light haze.                     |
| 31:208 p. m.                     | -12.8           | NW 3                  | 8                       | 11            | No clouds, light haze.                                     |

## POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy, Superintendent U. S. Naval Observatory. Data furnished by the U. S. Naval Observatory in cooperation with Harvard and Mount Wilson Observatories. The difference in longitude is measured from the central meridian, positive west. The north latitude is positive. Areas are corrected for foreshortening and are expressed in millionths of the sun's visible hemisphere. The total area for each day includes spots and groups]

| Date   | Eastern<br>stand-<br>ard<br>time |    | Heliographic               |                |               | Area |       | Total<br>area<br>for each<br>day | Observatory         |
|--------|----------------------------------|----|----------------------------|----------------|---------------|------|-------|----------------------------------|---------------------|
|        |                                  |    | Diff. in<br>longi-<br>tude | Longi-<br>tude | Lati-<br>tude | Spot | Group |                                  |                     |
| 1935   |                                  |    |                            |                |               |      |       |                                  |                     |
| Jan. 1 | h                                | m  | °                          | °              | °             |      |       |                                  | U. S. Naval.<br>Do. |
| Jan. 2 | 15                               | 12 | +28.0                      | 177.4          | -21.0         |      | 123   | 123                              |                     |
|        | 11                               | 34 | -80.0                      | 58.2           | -31.0         |      | 154   |                                  |                     |
|        |                                  |    | -70.0                      | 68.2           | -22.0         | 31   |       |                                  |                     |
|        |                                  |    | +41.0                      | 179.2          | -21.0         |      | 46    | 231                              |                     |
| Jan. 3 | 11                               | 14 | -67.0                      | 58.3           | -31.0         |      | 247   |                                  | Do.                 |
|        |                                  |    | +55.0                      | 180.3          | -21.0         |      | 62    | 309                              |                     |
| Jan. 4 | 11                               | 12 | -55.0                      | 57.1           | -31.0         |      | 185   | 185                              | Do.<br>Do.          |
| Jan. 5 | 11                               | 5  | -41.0                      | 58.0           | -31.0         |      | 185   | 185                              |                     |

| Date                        | Eastern<br>stand-<br>ard<br>time | Heliographic               |               |                | Area |       | Total<br>area<br>for each<br>day | Observatory  |
|-----------------------------|----------------------------------|----------------------------|---------------|----------------|------|-------|----------------------------------|--------------|
|                             |                                  | Diff. in<br>longi-<br>tude | Lati-<br>tude | Longi-<br>tude | Spot | Group |                                  |              |
| 1935                        |                                  |                            |               |                |      |       |                                  |              |
| Jan. 6                      | 13 15                            | -24.0                      | 60.6          | +29.0          | 9    |       |                                  | Mt. Wilson.  |
|                             |                                  | -22.0                      | 62.6          | -33.0          |      | 199   | 208                              |              |
| Jan. 7                      | 13 54                            | -15.0                      | 56.1          | -31.0          |      | 170   |                                  | U. S. Naval. |
|                             |                                  | -8.5                       | 62.6          | +30.0          | 15   |       | 185                              |              |
| Jan. 11                     | 11 21                            | -85.0                      | 294.8         | -19.0          |      | 154   |                                  | Do.          |
|                             |                                  | +38.0                      | 57.8          | -31.0          | 93   |       | 247                              |              |
| Jan. 12                     | 11 24                            | -73.0                      | 293.6         | -18.5          |      | 340   |                                  | Do.          |
|                             |                                  | +51.0                      | 57.6          | -32.0          | 77   |       | 417                              |              |
| Jan. 14                     | 11 40                            | -45.5                      | 294.6         | -19.0          |      | 278   |                                  | Do.          |
|                             |                                  | +76.0                      | 56.1          | -33.0          | 46   |       | 324                              |              |
| Jan. 15                     | 13 45                            | -33.0                      | 292.9         | -20.0          |      | 123   | 123                              | Do.          |
| Jan. 16                     | 14 45                            | -23.0                      | 289.1         | -19.0          | 15   |       |                                  | Do.          |
|                             |                                  | -17.0                      | 295.1         | -20.0          |      | 93    | 108                              |              |
| Jan. 17                     | 14 20                            | -2.5                       | 296.7         | -21.0          |      | 100   | 100                              | Do.          |
| Jan. 18                     | 11 0                             | +8.0                       | 295.8         | -21.0          |      | 111   | 111                              | Mt. Wilson.  |
| Jan. 19                     | 14 25                            | +22.0                      | 294.8         | -22.0          |      | 26    | 26                               | Do.          |
| Jan. 20                     | 11 30                            | +33.0                      | 294.2         | -22.5          |      | 45    | 45                               | Do.          |
| Jan. 21                     | 11 30                            | +47.0                      | 295.0         | -23.0          | 14   |       | 14                               | Do.          |
| Jan. 22                     | 18 15                            | -71.0                      | 160.2         | +28.0          | 16   |       |                                  | Do.          |
|                             |                                  | +63.0                      | 294.2         | -23.0          | 5    |       | 21                               |              |
| Jan. 23                     | 13 10                            | -62.0                      | 158.8         | +29.0          |      | 86    |                                  | Do.          |
|                             |                                  | +11.0                      | 231.8         | -28.5          |      | 71    | 157                              |              |
| Jan. 24                     | 11 13                            | -50.0                      | 158.7         | +29.0          |      | 123   |                                  | U. S. Naval. |
|                             |                                  | +24.0                      | 232.7         | -29.5          |      | 216   | 339                              |              |
| Jan. 25                     | 13 14                            | -37.5                      | 157.0         | +29.0          |      | 100   |                                  | Do           |
|                             |                                  | +39.0                      | 233.5         | -29.5          |      | 247   | 347                              |              |
| Jan. 26                     | 9 40                             | -24.0                      | 159.4         | +29.0          |      | 274   |                                  | Harvard.     |
|                             |                                  | +52.0                      | 235.4         | -31.0          |      | 373   | 647                              |              |
| Jan. 27                     | 13 28                            | -10.0                      | 158.0         | +29.0          |      | 93    |                                  | U. S. Naval. |
|                             |                                  | +66.0                      | 234.0         | -29.0          |      | 154   | 247                              |              |
| Jan. 28                     | 11 14                            | +3.0                       | 159.1         | +29.5          | 62   |       |                                  | Do.          |
|                             |                                  | +81.0                      | 237.1         | -30.0          | 77   |       | 139                              |              |
| Jan. 29                     | 14 18                            | +17.5                      | 158.7         | +30.0          | 62   |       | 62                               | Do.          |
| Jan. 30                     | 11 11                            | +29.0                      | 158.7         | +30.0          | 62   |       | 62                               | Do.          |
| Jan. 31                     | 11 18                            | +40.0                      | 156.5         | +30.0          | 62   |       | 62                               | Do.          |
| Mean daily area for 27 days |                                  |                            |               |                |      |       | 186                              |              |

## PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR JANUARY 1935

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgenossische Sternwarte, Zurich, Switzerland]

| January 1935 | Relative numbers | January 1935 | Relative numbers | January 1935 | Relative numbers |
|--------------|------------------|--------------|------------------|--------------|------------------|
| 1            | 35               | 11           | d 19             | 21           | 7                |
| 2            | d                | 12           |                  | 22           | 14               |
| 3            | 27               | 13           | 24               | 23           | ad 6             |
| 4            |                  | 14           |                  | 24           | 31               |
| 5            |                  | 15           | 16               | 25           | 32               |
| 6            | 21               | 16           | 16               | 26           | 31               |
| 7            | a 19             | 17           | a 14             | 27           | 26               |
| 8            | 11               | 18           | 12               | 28           | a 24             |
| 9            | 11               | 19           | 10               | 29           |                  |
| 10           | 9                | 20           | 9                | 30           | 9                |
|              |                  |              |                  | 31           | 10               |

Mean, 25 days=18.1.

a = Passage of an average-sized group through the central meridian.  
d = Entrance of a large or average-sized center of activity on the east limb.

## AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By L. T. SAMUELS

The departures shown in table 1 are based on "normals" that in most cases represent comparatively few observations. (See footnotes at bottom of table.) Free-air temperature departures were negative, except at Omaha, with the largest departures occurring at Boston. Relative humidity departures were negative, except over California, where they were positive. The monthly free-air temperatures averaged lowest over the northeastern part of the country, and highest over central Texas. Free-air relative humidities averaged highest over the Northwest, and lowest over the Gulf coast.

Table 2 has been revised so as to include, so far as possible, all of the airplane weather observation stations shown in table 1. The free-air resultant wind directions deviated mostly from normal over the Pacific coast, where a preponderance of southerly components occurred, and over the Ohio River Valley, where northerly components predominated. Elsewhere resultant directions were generally close to normal. Resultant free-air wind velocities were generally above normal over the middle Mississippi and Ohio River Valleys and over the western part of the country. Elsewhere these departures were mostly negative.

TABLE 1.—Free-air temperatures and relative humidities obtained by airplanes during January 1935

| TEMPERATURE (°C.)   |                            |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       |                        |                       |
|---|----------------------------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|-----------------------|-------|------------------------|-----------------------|
| Stations  | Altitude (meters) m. s. l. |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       |                       |       | Number of observations |                       |
|   | Surface                    |                       | 500   |                       | 1,000 |                       | 1,500 |                       | 2,000 |                       | 2,500 |                       | 3,000 |                       | 4,000 |                       | 5,000 |                        |                       |
|   | Mean                       | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  | Departure from normal | Mean  |                        | Departure from normal |
| Billings, Mont. <sup>1</sup> (1,088 m)                      | -6.9                       |                       |       |                       |       |                       | -2.4  |                       | -1.0  |                       | -3.0  |                       | -5.7  |                       | -12.5 |                       | -19.7 |                        | 31                    |
| Boston, Mass. <sup>2</sup> (6 m)                            | -6.8                       | -4.8                  | -7.2  | -3.4                  | -9.0  | -3.8                  | -9.5  | -3.6                  | -11.0 | -3.6                  | -12.8 | -3.5                  | -13.9 | -2.5                  | -18.6 | -1.8                  | -23.7 | -1.5                   | 11                    |
| Cheyenne, Wyo. <sup>1</sup> (1873 m)                        | -2.9                       |                       |       |                       |       |                       |       |                       | -0.9  |                       | 0.9   |                       | -1.6  |                       | -7.9  |                       | -14.8 |                        | 31                    |
| Fargo, N. Dak. <sup>1</sup> (274 m)                         | -18.5                      |                       | -17.4 |                       | -11.9 |                       | -8.6  |                       | -8.2  |                       | -9.4  |                       | -11.1 |                       | -16.4 |                       | -23.3 |                        | 36                    |
| Kelly Field (San Antonio), Tex. <sup>3</sup> (206 m)        | 9.2                        |                       | 11.7  |                       | 11.4  |                       | 11.1  |                       | 9.8   |                       | 7.8   |                       | 4.9   |                       | -0.4  |                       | -6.7  |                        | 29                    |
| Lakehurst, N. J. <sup>4</sup> (39 m)                        | 0.7                        |                       | 1.1   |                       | -1.2  |                       | -2.6  |                       | -4.1  |                       | -4.7  |                       | -6.9  |                       | -13.0 |                       | -21.6 |                        | 10                    |
| Maxwell Field (Montgomery), Ala. <sup>3</sup> (52 m)        | 6.9                        |                       | 8.3   |                       | 8.9   |                       | 8.6   |                       | 6.3   |                       | 3.7   |                       | 1.7   |                       | -3.1  |                       | -8.7  |                        | 29                    |
| Mitchel Field (Hempstead, L. I.), N. Y. <sup>3</sup> (29 m) | -4.6                       |                       | -4.7  |                       | -6.5  |                       | -6.9  |                       | -7.5  |                       | -8.3  |                       | -10.0 |                       | -15.4 |                       | -21.9 |                        | 15                    |
| Murfreesboro, Tenn. <sup>1</sup> (174 m)                    | 2.1                        |                       | 2.4   |                       | 2.5   |                       | 2.9   |                       | 2.1   |                       | 0.4   |                       | -1.7  |                       | -7.0  |                       | -13.3 |                        | 30                    |
| Norfolk, Va. <sup>4</sup> (10 m)                            | 3.6                        | -2.2                  | 2.8   | -2.4                  | 1.9   | -2.0                  | 1.3   | -1.2                  | 0.2   | -0.8                  | -1.2  | -0.5                  | -2.8  | -0.3                  | -7.7  | -0.3                  | -14.2 | -0.3                   | 24                    |
| Oklahoma City, Okla. <sup>1</sup> (391 m)                   | 3.0                        |                       | 4.1   |                       | 7.7   |                       | 7.2   |                       | 5.0   |                       | 2.7   |                       | -0.7  |                       | -6.9  |                       | -14.3 |                        | 29                    |
| Omaha, Nebr. <sup>1</sup> (300 m)                           | -7.5                       | -2.3                  | -6.7  | -2.6                  | -3.2  | -1.8                  | +0.1  | +0.4                  | -0.1  | +1.1                  | -1.7  | +1.8                  | -4.5  | +1.7                  | -10.2 | +2.0                  | -16.6 | +2.3                   | 30                    |
| Pearl Harbor, Hawaii <sup>4</sup> (6 m)                     | 19.7                       | -3.3                  | 19.3  | -0.4                  | 15.4  | -0.3                  | 12.1  | -1.0                  | 10.2  | -0.8                  | 8.7   | -0.4                  | 6.5   | -0.3                  | 1.4   | -0.3                  | -4.7  | -0.3                   | 39                    |
| Pensacola, Fla. <sup>4</sup> (24 m)                         | 6.3                        | -4.2                  | 8.5   | -2.0                  | 8.1   | -1.2                  | 7.4   | -0.6                  | 5.1   | -1.3                  | 3.5   | -0.9                  | 1.4   | -0.8                  | -3.9  | -0.7                  | -9.1  | -0.7                   | 20                    |
| San Diego, Calif. <sup>4</sup> (10 m)                       | 9.6                        | -2.2                  | 12.3  | +0.3                  | 10.6  | +0.1                  | 8.3   | 0.0                   | 5.7   | -0.2                  | 3.4   | -0.1                  | 1.1   | 0.0                   | -4.6  | +0.7                  | -11.4 | +0.7                   | 29                    |
| Scott Field (Belleville), Ill. <sup>3</sup> (135 m)         | -4.1                       |                       | -3.7  |                       | -0.8  |                       | 0.0   |                       | -0.6  |                       | -1.7  |                       | -4.1  |                       | -8.7  |                       | -15.2 |                        | 22                    |
| Seattle, Wash. <sup>4</sup> (25 m)                          | 4.8                        |                       | 6.1   |                       | 5.3   |                       | 2.8   |                       | -0.3  |                       | -3.2  |                       | -6.0  |                       | -12.3 |                       | -19.3 |                        | 12                    |
| Selfridge Field (Mount Clemens), Mich. <sup>3</sup> (177 m) | -7.2                       |                       | -8.1  |                       | -8.9  |                       | -8.7  |                       | -9.3  |                       | -10.8 |                       | -13.0 |                       | -18.3 |                       | -23.8 |                        | 25                    |
| Spokane, Wash. <sup>4</sup> (596 m)                         | 2.5                        |                       |       |                       | 5.9   |                       | 6.5   |                       | 5.1   |                       | 2.5   |                       | -0.3  |                       | -6.1  |                       | -12.5 |                        | 10                    |
| Sunnyvale, Calif. <sup>4</sup> (10 m)                       | 6.8                        | -1.9                  | 8.2   | -0.3                  | 8.3   | -0.4                  | 6.0   | -1.2                  | 3.2   | -1.8                  | 0.5   | -1.9                  | -2.2  | -1.9                  | -7.5  | -1.0                  | -13.5 | -1.0                   | 24                    |
| Washington, D. C. <sup>4</sup> (13 m)                       | -3.1                       | -3.3                  | -3.4  | -3.8                  | -4.5  | -3.9                  | -4.8  | -3.1                  | -5.1  | -2.2                  | -6.0  | -1.8                  | -7.6  | -1.5                  | -11.3 | -1.4                  | -17.0 | -1.4                   | 18                    |
| Wright Field (Dayton) Ohio <sup>3</sup> (244 m)             | -3.5                       |                       | -3.9  |                       | -4.0  |                       | -3.2  |                       | -3.7  |                       | -5.4  |                       | -7.2  |                       | -11.4 |                       | -17.0 |                        | 24                    |

| RELATIVE HUMIDITY (PERCENT)                                 |    |     |    |     |    |     |    |     |    |     |    |    |    |    |    |    |    |     |
|---|----|-----|----|-----|----|-----|----|-----|----|-----|----|----|----|----|----|----|----|-----|
| Billings, Mont. <sup>1</sup> (1088 m)                       | 64 |     |    |     |    |     | 55 |     | 48 |     | 49 |    | 53 |    | 59 |    | 60 |     |
| Boston, Mass. <sup>2</sup> (6 m)                            | 68 | -3  | 65 | -5  | 64 | -6  | 62 | -5  | 60 | -5  | 58 | -4 | 58 | -2 | 52 | -7 | 50 | -7  |
| Cheyenne, Wyo. <sup>1</sup> (1873 m)                        | 53 |     |    |     |    |     | 51 |     | 51 |     | 44 |    | 42 |    | 40 |    | 39 |     |
| Fargo, N. Dak. <sup>1</sup> (274 m)                         | 87 |     | 80 |     | 72 |     | 68 |     | 62 |     | 60 |    | 58 |    | 54 |    | 52 |     |
| Kelly Field (San Antonio), Tex. <sup>3</sup> (206 m)        | 85 |     | 71 |     | 67 |     | 56 |     | 47 |     | 40 |    | 39 |    | 34 |    | 28 |     |
| Lakehurst, N. J. <sup>4</sup> (39 m)                        | 73 |     | 74 |     | 74 |     | 67 |     | 60 |     | 54 |    | 54 |    | 47 |    | 41 |     |
| Maxwell Field (Montgomery), Ala. <sup>3</sup> (52 m)        | 81 |     | 68 |     | 61 |     | 49 |     | 49 |     | 48 |    | 44 |    | 34 |    | 35 |     |
| Mitchel Field (Hempstead, L. I.), N. Y. <sup>3</sup> (29 m) | 68 |     | 65 |     | 63 |     | 61 |     | 59 |     | 60 |    | 58 |    | 58 |    | 55 |     |
| Murfreesboro, Tenn. <sup>1</sup> (174 m)                    | 78 |     | 74 |     | 68 |     | 59 |     | 56 |     | 54 |    | 54 |    | 47 |    | 47 |     |
| Norfolk, Va. <sup>4</sup> (10 m)                            | 69 | -4  | 65 | -3  | 60 | -3  | 55 | -3  | 49 | -3  | 45 | -3 | 41 | -3 | 40 | -3 | 44 | -3  |
| Oklahoma City, Okla. <sup>1</sup> (391 m)                   | 75 |     | 72 |     | 59 |     | 48 |     | 42 |     | 38 |    | 36 |    | 34 |    | 34 |     |
| Omaha, Nebr. <sup>1</sup> (300 m)                           | 81 | -1  | 76 | -2  | 63 | -3  | 54 | -3  | 47 | -3  | 44 | -5 | 45 | -4 | 46 | 0  | 42 | -1  |
| Pearl Harbor, Hawaii <sup>4</sup> (6 m)                     | 81 | +10 | 76 | +2  | 78 | +1  | 75 | +5  | 67 | +6  | 56 | +6 | 48 | +8 | 40 | +8 | 34 | +8  |
| Pensacola, Calif. <sup>4</sup> (24 m)                       | 73 | -8  | 62 | -12 | 58 | -10 | 52 | -10 | 46 | -10 | 43 | -9 | 39 | -9 | 32 | -9 | 24 | -10 |
| San Diego, Calif. <sup>4</sup> (10 m)                       | 82 | +13 | 64 | +4  | 58 | +6  | 52 | +5  | 46 | +5  | 38 | +2 | 35 | +3 | 32 | +3 | 30 | +3  |
| Scott Field (Belleville), Ill. <sup>3</sup> (135 m)         | 80 |     | 69 |     | 54 |     | 47 |     | 45 |     | 41 |    | 41 |    | 36 |    | 36 |     |
| Seattle, Wash. <sup>4</sup> (25 m)                          | 83 |     | 71 |     | 64 |     | 61 |     | 61 |     | 59 |    | 56 |    | 50 |    | 53 |     |
| Selfridge Field (Mount Clemens), Mich. <sup>3</sup> (177 m) | 81 |     | 76 |     | 66 |     | 54 |     | 48 |     | 46 |    | 46 |    | 48 |    | 48 |     |
| Spokane, Wash. <sup>4</sup> (596 m)                         | 86 |     |    |     | 68 |     | 63 |     | 59 |     | 64 |    | 65 |    | 64 |    | 64 |     |
| Sunnyvale, Calif. <sup>4</sup> (10 m)                       | 89 | +7  | 73 | +1  | 62 | +2  | 58 | +4  | 54 | +6  | 47 | +5 | 42 | +4 | 39 | +2 | 39 | +2  |
| Washington, D. C. <sup>4</sup> (13 m)                       | 64 | -6  | 60 | -2  | 56 | -2  | 52 | -3  | 47 | -4  | 43 | -4 | 41 | -2 | 41 | -3 | 44 | -3  |
| Wright Field (Dayton), Ohio <sup>3</sup> (244 m)            | 80 |     | 78 |     | 71 |     | 60 |     | 52 |     | 52 |    | 49 |    | 43 |    | 40 |     |

Observations taken about 5:00 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are taken at dawn.

<sup>1</sup> Weather Bureau.<sup>2</sup> Massachusetts Institute of Technology.<sup>3</sup> Army.<sup>4</sup> Navy.<sup>5</sup> National Guard.

NOTE.—Boston normals based on 57 observations; Norfolk normals based on 79 observations; Omaha normals based on 119 observations; Pearl Harbor normals based on 91 observations; Pensacola normals based on 128 observations; San Diego normals based on 151 observations; Sunnyvale normals based on 51 observations; Washington normals based on 130 observations.

TABLE 2.—Free-air resultant winds (meters per second) based on pilot balloon observations made near 6 a. m. (E. S. T.) during January 1935

[Wind from N=360°, E=90°, etc.]

| Altitude<br>(m) m. s. l. | Albuquerque,<br>N. Mex.<br>(1,554 m) |          | Atlanta,<br>Ga.<br>(309 m) |          | Billings,<br>Mont.<br>(1,088 m) |          | Boston,<br>Mass.<br>(15 m) |          | Cheyenne,<br>Wyo.<br>(1,873 m) |          | Chicago,<br>Ill. (192 m) |          | Cincinnati,<br>Ohio,<br>(163 m) |          | Detroit,<br>Mich.<br>(204 m) |          | Fargo,<br>N. Dak.<br>(274 m) |          | Houston,<br>Tex. (21 m) |          | Key West,<br>Fla. (11 m) |          | Medford,<br>Oreg.<br>(410 m) |          | Murfrees-<br>boro, Tenn.<br>(189 m) |          |
|--------------------------|--------------------------------------|----------|----------------------------|----------|---------------------------------|----------|----------------------------|----------|--------------------------------|----------|--------------------------|----------|---------------------------------|----------|------------------------------|----------|------------------------------|----------|-------------------------|----------|--------------------------|----------|------------------------------|----------|-------------------------------------|----------|
|                          | Direction                            | Velocity | Direction                  | Velocity | Direction                       | Velocity | Direction                  | Velocity | Direction                      | Velocity | Direction                | Velocity | Direction                       | Velocity | Direction                    | Velocity | Direction                    | Velocity | Direction               | Velocity | Direction                | Velocity | Direction                    | Velocity | Direction                           | Velocity |
| Surface.....             | 354                                  | 1.1      | 337                        | 2.3      | 240                             | 2.6      | 305                        | 3.1      | 282                            | 6.0      | 294                      | 2.5      | 310                             | 1.0      | 242                          | 1.8      | 313                          | 1.2      | 41                      | 0.4      | 26                       | 2.5      | 142                          | 0.9      | 193                                 | 0.3      |
| 500.....                 | 352                                  | 3.1      | 352                        | 3.1      | 300                             | 7.3      | 300                        | 7.3      | 280                            | 4.2      | 247                      | 3.4      | 254                             | 5.3      | 254                          | 5.3      | 315                          | 3.4      | 254                     | 1.2      | 40                       | 3.3      | 147                          | 1.3      | 210                                 | 2.1      |
| 1,000.....               | 309                                  | 3.6      | 309                        | 3.6      | 302                             | 7.6      | 302                        | 7.6      | 278                            | 6.3      | 254                      | 6.7      | 268                             | 8.4      | 281                          | 6.5      | 301                          | 3.0      | 301                     | 3.0      | 82                       | 1.6      | 166                          | 4.6      | 241                                 | 4.8      |
| 1,500.....               | 301                                  | 6.5      | 301                        | 6.5      | 241                             | 8.2      | 298                        | 10.1     | 278                            | 9.6      | 295                      | 8.3      | 283                             | 7.5      | 273                          | 9.7      | 319                          | 3.8      | 319                     | 3.8      | 50                       | 0.9      | 216                          | 6.1      | 287                                 | 7.0      |
| 2,000.....               | 302                                  | 2.4      | 303                        | 7.9      | 266                             | 8.9      | 311                        | 12.6     | 279                            | 7.4      | 284                      | 11.5     | 309                             | 8.6      | 304                          | 10.1     | 286                          | 12.7     | 304                     | 5.7      | 6                        | 1.1      | 235                          | 9.8      | 316                                 | 8.8      |
| 2,500.....               | 288                                  | 4.2      | 306                        | 8.1      | 275                             | 12.1     | 288                        | 12.5     | 275                            | 12.0     | 288                      | 13.2     | 322                             | 11.4     | 314                          | 12.9     | 289                          | 17.0     | 297                     | 5.7      | 305                      | 2.8      | 234                          | 10.0     | 308                                 | 11.1     |
| 3,000.....               | 274                                  | 7.1      | 304                        | 9.8      | 283                             | 12.4     | 280                        | 10.7     | 280                            | 10.7     | 301                      | 15.3     | 313                             | 14.2     | 313                          | 14.2     | 282                          | 6.1      | 282                     | 6.1      | 300                      | 4.4      | 260                          | 9.9      | 300                                 | 11.0     |
| 4,000.....               | 271                                  | 9.9      | 276                        | 12.3     | 276                             | 12.3     | 280                        | 11.3     | 280                            | 11.3     | 308                      | 8.8      | 308                             | 8.8      | 308                          | 8.8      | 282                          | 9.2      | 282                     | 9.2      | 308                      | 6.8      | 282                          | 9.2      | 308                                 | 6.8      |
| 5,000.....               | 279                                  | 8.5      | 279                        | 8.5      | 279                             | 8.5      | 279                        | 8.5      | 279                            | 8.5      | 279                      | 8.5      | 279                             | 8.5      | 279                          | 8.5      | 279                          | 8.5      | 279                     | 8.5      | 279                      | 8.5      | 279                          | 8.5      | 279                                 | 8.5      |

| Altitude<br>(m) m. s. l. | Newark,<br>N. J.<br>(14 m) |          | Oakland,<br>Calif.<br>(8 m) |          | Oklahoma<br>City, Okla.<br>(402 m) |          | Omaha,<br>Nebr.<br>(306 m) |          | Pearl Har-<br>bor, Terri-<br>tory of Ha-<br>waii (68 m) |          | Pensacola,<br>Fla. (24 m) |          | St. Louis,<br>Mo. (179 m) |          | Salt Lake<br>City, Utah<br>(1,294 m) |          | San Diego,<br>Calif.<br>(15 m) |          | Sault Ste.<br>Marie,<br>Mich.<br>(198 m) |          | Seattle,<br>Wash.<br>(14 m) |          | Spokane,<br>Wash.<br>(603 m) |          | Washing-<br>ton, D. C.<br>(10 m) |          |
|--------------------------|----------------------------|----------|-----------------------------|----------|------------------------------------|----------|----------------------------|----------|---|----------|---------------------------|----------|---------------------------|----------|--------------------------------------|----------|--------------------------------|----------|--|----------|-----------------------------|----------|------------------------------|----------|----------------------------------|----------|
|                          | Direction                  | Velocity | Direction                   | Velocity | Direction                          | Velocity | Direction                  | Velocity | Direction   | Velocity | Direction                 | Velocity | Direction                 | Velocity | Direction                            | Velocity | Direction                      | Velocity | Direction                                | Velocity | Direction                   | Velocity | Direction                    | Velocity | Direction                        | Velocity |
| Surface.....             | 312                        | 2.5      | 114                         | 1.4      | 198                                | 0.8      | 24                         | 0.9      | 40  | 0.2      | 32                        | 2.3      | 270                       | 1.4      | 171                                  | 2.0      | 73                             | 1.1      | 85                                       | 1.2      | 164                         | 1.9      | 189                          | 2.4      | 335                              | 1.9      |
| 500.....                 | 315                        | 7.3      | 6                           | 0.4      | 194                                | 3.2      | 264                        | 1.9      | 224   | 0.8      | 35                        | 1.3      | 271                       | 4.3      | 194                                  | 0.7      | 194                            | 0.7      | 299                                      | 0.9      | 190                         | 5.9      | 221                          | 9.0      | 318                              | 5.3      |
| 1,000.....               | 313                        | 10.3     | 241                         | 2.7      | 244                                | 4.2      | 274                        | 4.4      | 224   | 1.5      | 282                       | 2.3      | 300                       | 7.8      | 229                                  | 1.0      | 229                            | 1.0      | 298                                      | 8.3      | 188                         | 7.6      | 206                          | 6.1      | 307                              | 7.8      |
| 1,500.....               | 317                        | 8.9      | 240                         | 3.9      | 255                                | 4.9      | 279                        | 8.4      | 223   | 1.8      | 286                       | 3.8      | 297                       | 9.3      | 168                                  | 3.2      | 199                            | 1.7      | 311                                      | 11.2     | 197                         | 7.8      | 221                          | 9.0      | 293                              | 10.4     |
| 2,000.....               | 317                        | 13.0     | 235                         | 4.9      | 272                                | 6.8      | 298                        | 11.8     | 222   | 1.8      | 253                       | 3.3      | 298                       | 12.1     | 184                                  | 6.6      | 205                            | 1.9      | 200                                      | 8.6      | 200                         | 8.6      | 257                          | 7.9      | 291                              | 13.1     |
| 2,500.....               | 240                        | 5.3      | 249                         | 5.3      | 283                                | 7.4      | 295                        | 15.5     | 241   | 1.8      | 302                       | 13.0     | 213                       | 5.4      | 239                                  | 2.3      | 210                            | 9.0      | 210                                      | 9.0      | 210                         | 9.0      | 247                          | 9.9      | 298                              | 15.3     |
| 3,000.....               | 260                        | 6.6      | 260                         | 6.6      | 286                                | 6.9      | 299                        | 16.0     | 281   | 1.3      | 310                       | 14.2     | 246                       | 6.1      | 258                                  | 2.4      | 258                            | 2.4      | 258                                      | 2.4      | 258                         | 2.4      | 258                          | 2.4      | 258                              | 2.4      |
| 4,000.....               | 234                        | 8.2      | 234                         | 8.2      | 283                                | 10.0     | 283                        | 10.0     | 283   | 10.0     | 283                       | 10.0     | 283                       | 10.0     | 283                                  | 10.0     | 283                            | 10.0     | 283                                      | 10.0     | 283                         | 10.0     | 283                          | 10.0     | 283                              | 10.0     |
| 5,000.....               | 300                        | 6.7      | 300                         | 6.7      | 300                                | 6.7      | 300                        | 6.7      | 300   | 6.7      | 300                       | 6.7      | 300                       | 6.7      | 300                                  | 6.7      | 300                            | 6.7      | 300                                      | 6.7      | 300                         | 6.7      | 300                          | 6.7      | 300                              | 6.7      |

† Navy stations.

## RIVERS AND FLOODS

[River and Flood Division, MONTROSE W. HAYES, in charge]

By RICHMOND T. ZOCH

Although there were numerous floods in the eastern half of the United States in January, as shown in the accompanying flood table, none of those for which complete reports are available caused more than slight damage. Timely warnings were issued for each of these floods.

Complete reports are not available for the floods in the Connecticut River in New England and the Tallahatchie River in Mississippi. The significant features of these floods will be described in a later issue of the MONTHLY WEATHER REVIEW.

Local floods in small streams where the flood warning service is not maintained were reported in the Bull Hook Creek, near Havre, Mont.; in portions of the State of Washington; and near Memphis, Tenn. The official in charge of the Memphis, Tenn., Weather Bureau office comments as follows on the last-mentioned flood:

There are no gages and the Weather Bureau does not furnish a flood-warning service on the following streams of Shelby County, Tenn.: Wolf River, which flows into the Mississippi at Memphis; Loosahatchie River which flows into the Mississippi a few miles north of Memphis; and Nonconah Creek, which flows into the Mississippi on the southern outskirts of Memphis. All of the above streams overflowed their banks on January 20, 1935, and during the night of the 21st reached unprecedented high stages, at least unprecedented for the last 2 decades. The precipitation

at Memphis during the preceding days was 0.59 on January 18, 3.74 on January 19, and 3.74 on January 20, making a total of 8.07 inches in 3 days.

The heavy rainfall was general throughout the Memphis area. A trace of sleet, and 3.2 inches of snow, fell on the 21st. A cold wave occurred on the 21-22, reaching a minimum temperature of 12° on the 22d. The weather continued cold for the next several days, adding to the suffering of livestock, and increasing traffic hazards. All highway traffic into Memphis was halted on the 21st due to washed out roads and bridges, and water on the highways to a considerable depth in places, with the exception of one highway from the east and highways to the west. Several railroads leading into Memphis had to run their trains over other lines for several days until repairs could be made. The Shelby County engineer conservatively estimates the damage to roads and bridges in Shelby County at \$100,000. Owing to the comparatively low stage of the Mississippi River at Memphis on January 21 and the high water in Wolf River, there was a "run-out" on Wolf River on that date. Shortly after noon of the 21st several steamboats, not steamed up, broke from their moorings on Wolf River at the Anderson-Tully Lumber Co. and were carried rapidly downstream by the swift current, crashing and tearing loose other water craft and floating equipment. By the time the runaways reached the Mississippi River there were nearly 50 pieces of river craft in the wreck, including launches, motorboats, steamboats, dredges, dry-docks, pontoons, and other floating equipment. The United States steamboat inspectors estimate this damage at approximately \$100,000. An unestimated number of hogs and cows were drowned, and probably a small number of other livestock.

The total damage of this flood is conservatively estimated at over \$200,000.

Table of flood stages in January 1935

[All dates in January, unless otherwise specified]

| River and station                           | Flood stage | Above flood stages—dates |        | Crest |         |
|---|-------------|--------------------------|--------|-------|---------|
|   |             | From—                    | To—    | Stage | Date    |
| ATLANTIC SLOPE DRAINAGE                     |             |                          |        |       |         |
| Connecticut:                                | Feet        |                          |        | Feet  |         |
| White River Junction, Vt.                   | 18          | 10                       | 10     | 18.1  | 10      |
| Hartford, Conn.                             | 16          | 11                       | 14     | 20.7  | 12      |
| Hudson: Troy, N. Y.                         | 15          | 10                       | 11     | 16.4  | 10      |
| Chenango: Sherburne, N. Y.                  | 8           | 9                        | 11     | 9.7   | 9       |
| Susquehanna:                                |             |                          |        |       |         |
| Oneonta, N. Y.                              | 12          | 9                        | 12     | 16.7  | 11      |
| Bainbridge, N. Y.                           | 11          | 9                        | 12     | 15.8  | 11      |
| Binghamton, N. Y.                           | 14          | 9                        | 11     | 16.75 | 10      |
| Towanda, Pa.                                | 16          | 10                       | 11     | 16.5  | 10      |
| James:                                      |             |                          |        |       |         |
| Buchanan, Va.                               | 17          | 22                       | 24     | 24.5  | 23      |
| Lynchburg, Va.                              | 18          | 23                       | 24     | 22.0  | 23      |
| Columbia, Va.                               | 10          | 22                       | 28     | 30.3  | 24      |
| Richmond, Va.                               | 8           | 23                       | 27     | 18.8  | 25      |
| Roanoke:                                    |             |                          |        |       |         |
| Randolph, Va.                               | 18          | 24                       | 25     | 24.8  | 25      |
| Weldon, N. C.                               | 31          | 24                       | 27     | 38.3  | 26      |
| Williamston, N. C.                          | 10          | 28                       | Feb. 3 | 11.4  | 31      |
| Cape Fear: Lock No. 2, Elizabethtown, N. C. | 20          | 3                        | 4      | 23.7  | 3       |
| Saluda: Pelzer, S. C.                       | 7           | 10                       | 11     | 8.3   | 10      |
| Santee:                                     |             |                          |        |       |         |
| Rimini, S. C.                               | 12          | { 2                      | 5      | 13.0  | 5       |
|   |             | { 11                     | 14     | 12.9  | 12      |
|   |             | { 26                     | 27     | 12.9  | 27      |
| Ferguson, S. C.                             | 12          | 13                       | 17     | 12.3  | 14, 15  |
| Savannah: Ellenton, S. C.                   | 14          | { 3                      | 6      | 17.8  | 4       |
|   |             | { 11                     | 16     | 20.0  | 13      |
| EAST GULF OF MEXICO DRAINAGE                |             |                          |        |       |         |
| Tombigbee:                                  |             |                          |        |       |         |
| Lock No. 3, Ala.                            | 33          | { Dec. 29                | 7      | 39.2  | Dec. 30 |
| Lock No. 1, Ala.                            | 31          | { 24                     | 30     | 36.8  | 26      |
|   |             | { 1                      | 7      | 31.4  | 6       |
| Pearl:                                      |             |                          |        |       |         |
| Jackson, Miss.                              | 18          | { Dec. 27                | 12     | 24.5  | 2-4     |
| Monticello, Miss.                           | 15          | { 23                     | Feb. 2 | 23.0  | 26      |
|   |             | { 23                     | 24     | 15.3  | 23      |
| Pearl River, La.                            | 12          | { 3                      | 18     | 13.6  | 7       |
|   |             | { 26                     | Feb. 5 | 13.6  | 29      |
| MISSISSIPPI SYSTEM                          |             |                          |        |       |         |
| Upper Mississippi Basin                     |             |                          |        |       |         |
| Illinois:                                   |             |                          |        |       |         |
| Morris, Ill.                                | 13          | 9                        | 10     | 13.05 | 9, 10   |
| Peru, Ill.                                  | 17          | 11                       | 11     | 17.1  | 11      |
| Ohio Basin                                  |             |                          |        |       |         |
| Gauley: Summersville, W. Va.                | 10          | { 17                     | 18     | 11.76 | 17      |
|   |             | { 21                     | 23     | 11.46 | 23      |
| New: Glenlyn, Va.                           | 11          | 23                       | 23     | 11.4  | 23      |
| Barren: Bowling Green, Ky.                  | 20          | 20                       | 25     | 34.4  | 23      |

Table of flood stages in January 1935—Continued

[All dates in January, unless otherwise specified]

| River and station                  | Flood stage | Above flood stages—dates |        | Crest |        |
|------------------------------------|-------------|--------------------------|--------|-------|--------|
|                                    |             | From—                    | To—    | Stage | Date   |
| MISSISSIPPI SYSTEM—continued       |             |                          |        |       |        |
| Ohio Basin—Continued               |             |                          |        |       |        |
| Green:                             | Feet        |                          |        | Feet  |        |
| Lock No. 6, Brownsville, Ky.....   | 28          | 20                       | 27     | 43.4  | 23     |
| Lock No. 4, Woodbury, Ky.....      | 33          | 20                       | 29     | 48.1  | 24     |
| Lock No. 2, Rumsey, Ky.....        | 34          | 22                       | Feb. 5 | 41.6  | 30     |
| West Fork: Edwardsport, Ind.....   | 12          | 23                       | 24     | 13.0  | 24     |
| Cumberland:                        |             |                          |        |       |        |
| Celina, Tenn.....                  | 28          | 21                       | 24     | 36.0  | 23     |
| Clarksville, Tenn.....             | 46          | 21                       | 25     | 49.7  | 22     |
| Lock F, Eddyville, Ky.....         | 50          | 22                       | 29     | 55.7  | 25     |
| North Fork: Mendota, Va.....       | 8           | 23                       | 23     | 10.3  | 23     |
| Nolichucky: Embreeville, Tenn..... | 8           | 9                        | 9      | 10.3  | 9      |
| French Broad:                      |             |                          |        |       |        |
| Asheville, N. C.....               | 6           | 9                        | 11     | 8.3   | 9      |
| Oldtown, Tenn.....                 | 8           | 9                        | 9      | 9.5   | 9      |
| Ohio:                              |             |                          |        |       |        |
| Dam No. 25.....                    | 40          | 25                       | 25     | 41.1  | 25     |
| Dam No. 47, Newburgh, Ind.....     | 35          | 28                       | 30     | 35.3  | 29     |
| Evansville, Ind.....               | 35          | 26                       | 30     | 35.8  | 29     |
| Dam No. 50, Fords Ferry, Ky.....   | 34          | 24                       | Feb. 2 | 36.9  | 28-30  |
| White Basin                        |             |                          |        |       |        |
| Black: Black Rock, Ark.....        | 14          | 21                       | 28     | 18.1  | 21     |
| White: Clarendon, Ark.....         | 26          | 29                       | Feb. 6 | 26.3  | Feb. 3 |
| Arkansas Basin                     |             |                          |        |       |        |
| Petit Jean: Danville, Ark.....     | 20          | 20                       | 24     | 24.66 | 22     |
| Red Basin                          |             |                          |        |       |        |
| Onachita:                          |             |                          |        |       |        |
| Arkadelphia, Ark.....              | 17          | 20                       | 23     | 25.62 | 21     |
| Camden, Ark.....                   | 26          | 22                       | 31     | 37.11 | 25     |
| Little: Whitecliffs, Ark.....      | 25          | 22                       | 27     | 27.9  | 23     |
| Sulphur:                           |             |                          |        |       |        |
| Ringo Crossing, Tex.....           | 20          | 19                       | 25     | 27.2  | 21     |
| Naples, Tex.....                   | 22          | 22                       | 31     | 30.0  | 24     |
| Lower Mississippi Basin            |             |                          |        |       |        |
| Big Lake Outlet: Manila, Ark.....  | 10          | 3                        | (1)    | 16.8  | 28, 29 |
| St. Francis:                       |             |                          |        |       |        |
| Fisk, Mo.....                      | 20          | 20                       | 26     | 23.4  | 23     |
| St. Francis, Ark.....              | 18          | 21                       | (1)    | 21.7  | 26     |
| Tallahatchie: Swan Lake, Miss..... | 26          | 10                       | (1)    | (1)   | (1)    |

<sup>1</sup> Continued into February.

## WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

(The Marine Division, W. F. McDONALD in Charge)

## NORTH ATLANTIC OCEAN, JANUARY 1935

By H. C. HUNTER

**Atmospheric pressure.**—The average pressure during January was greater than normal over most of the North Atlantic, and was especially high, compared with normal, over the northeastern area. At Valencia, Ireland, the month averaged 0.5 inch above normal pressure, or 1.05 inches higher than during the month preceding. A period of particularly high pressure over the waters adjacent to the British Isles was noted from the 15th to 22d.

The southeastern portion of the North Atlantic averaged slightly above normal in pressure, and from the 21st to the end of the month this region was almost constantly much above normal.

One considerable part of the North Atlantic, the southwestern, had pressure averaging moderately less than normal. Bermuda averaged for the month 0.07 inch lower than normal pressure, and was nearly always below during the last 9 days of the month.

The highest reading reported was 30.86 inches, by the American steamship *Collamer* during the forenoon of the 21st, at about latitude 50° N., longitude 12° W. The

lowest reading was 28.45 inches, noted by the Dutch steamer *Leerdam*, very late on the 14th, at about 43° N., 62° W., near the center of a well-developed storm. These pressure extremes were from three to six tenths of an inch higher than those of the preceding month.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, January 1935

| Station                   | Average pressure | Departure | Highest | Date   | Lowest | Date |
|---------------------------|------------------|-----------|---------|--------|--------|------|
|                           | Inches           | Inch      | Inches  |        | Inches |      |
| Julianehaab, Greenland    | 29.52            |           | 30.15   | 22, 25 | 28.93  | 15   |
| Reykjavik, Iceland        | 29.74            | +0.28     | 30.39   | 4      | 28.74  | 9    |
| Lerwick, Shetland Islands | 30.01            | +0.31     | 30.80   | 18     | 28.52  | 25   |
| Valencia, Ireland         | 30.40            | +0.50     | 30.83   | 21     | 29.84  | 25   |
| Lisbon, Portugal          | 30.24            | +0.09     | 30.47   | 12     | 30.03  | 19   |
| Madeira                   | 30.13            | +0.03     | 30.32   | 26     | 29.94  | 10   |
| Horta, Azores             | 30.23            | +0.07     | 30.58   | 30     | 29.94  | 18   |
| Belle Isle, Newfoundland  | 29.85            | +0.05     | 30.52   | 29     | 28.88  | 3    |
| Halifax, Nova Scotia      | 30.02            | +0.04     | 30.72   | 5      | 28.88  | 2    |
| Nantucket                 | 30.10            | +0.06     | 30.82   | 5      | 29.28  | 1    |
| Hatteras                  | 30.16            | +0.02     | 30.62   | 5      | 29.61  | 23   |
| Bermuda                   | 30.09            | -0.07     | 30.48   | 5      | 29.68  | 10   |
| Turks Island              | 30.01            | -0.04     | 30.11   | 20     | 29.85  | 10   |
| Key West                  | 30.08            | -0.02     | 30.28   | 30     | 29.86  | 9    |
| New Orleans               | 30.17            | +0.04     | 30.53   | 24     | 29.78  | 8    |

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

**Cyclones and gales.**—The month was notably stormy in North Atlantic waters. However, only about two-thirds as many reports of gales have been received as for December 1934 while the number of reports of winds of forces 12 and 11 is only one-fifth the number for December.

The month began with one Low centered to east-north-eastward of Newfoundland and a second approaching the Atlantic coast of North America. The latter soon developed into one of the most intense Atlantic storms of the month; the forenoon of the 2d found it central near the southern part of the Gulf of St. Lawrence, as shown by chart IX. The further advance of the storm was toward southern Greenland, the intensity being still very great for about 3 days. During the night of the 2d-3d the British M. S. *Silversand* and the American S. S. *Steel Trader* encountered winds of hurricane strength when near the 55th meridian, within the area of this storm.

From the 4th to the 10th very few vessels encountered gales anywhere in the North Atlantic; but thereafter for a fortnight a considerable number were met. Especially notable was the period from the 12th to the 15th. On the former date low pressure prevailed near the 55th meridian from southern Greenland to about the 40th parallel, with several centers indicated. By the morning of the 14th, while pressure continued low around Cape Farewell, the centers to the southward had advanced in a northeasterly direction and a new storm of great energy was central a short distance to eastward of Nantucket. On the 15th this storm was near Cape Race and still very intense, the low barometer of the *Leerdam*, already mentioned, having been observed a few hours before. This situation is indicated on chart X. On the next 2 days this storm traveled rapidly northeastward and the chief steamship routes became less subject to gales.

During the 21st and 22d a storm central between Bermuda and the Azores developed considerable strength, and the third January instance of force 12 was noted about 1 p. m. the 22d, near 34° N., 44° W., by the Italian S. S. *Valrossa*. The storm kept about the same position for several days, losing energy till it was no longer perceptible. Meanwhile another Low had shown great strength over the waters close to the American coast. On the evening of the 22d the latter storm was central over the Carolinas, whence it moved first east-northeastward, then northeastward, to the Straits of Belle Isle by the morning of the 25th. Marked strength was shown during the 23d and 24th, and navigation near the coast was hampered not alone by high wind, but over a large area by heavy snow. In the waters between the Chesapeake capes and Delaware Bay three coal barges were sunk with loss of 13 lives.

From the 26th to the end of January there were comparatively few gales in Atlantic waters, especially of force more than 9.

Reports indicate a strong norther at and near Vera Cruz, Mexico, during the 19th and the first part of the 20th. No other notable winds were reported from the southwestern part of the Gulf of Mexico, but the eastern part experienced high winds from the 21st to 23d. In much of the Caribbean area the trade winds were reported as unusually strong from the 18th to the 21st, especially to northward of the Isthmus of Panama and thence eastward and northeastward to the 70th meridian.

**Fog.**—Except in very few areas, chiefly near to westward of Ireland, more fog was reported during Jan-

uary than during the preceding month. To southward of the 50th parallel several of the 5° squares in the eastern North Atlantic had more fog than is usual during January, and in particular the first 3 days of the month found widespread fog in this region.

In the Grand Banks area there was usually more than the normal January foginess, especially near and directly to eastward of Newfoundland. The square from 45° to 50° N., 45° to 50° W., experienced fog on 9 days, chiefly near the end of the month.

Along the American coast from Nova Scotia to the Carolinas fog prevailed more frequently than is usual in January, the periods from 7th to 11th and 21st to 23d being notably foggy to northward of Hatteras. There were several collisions and groundings due to the fog of the earlier period but without serious damage. The coastal waters in the square 35° to 40° N., 75° to 80° W., furnished records of fog occurrence on 10 days during January. There was comparatively little fog in the Gulf of Mexico and the dates of occurrence there were well scattered.

#### SEA SURFACE TEMPERATURE SUMMARY FOR THE EXTREME SOUTHEASTERN GULF OF MEXICO, 1912-33

By GILES SLOCUM

The area embraced in this summary comprises the three 1° squares, 23° N. to 24° N., and 84° W. to 87° W. This area lies immediately north of the Yucatan Channel.

The table shows monthly mean sea-surface temperatures, computed to whole degrees for the period 1912 to 1920, inclusive, when observations were few in number, and to one decimal place for the years 1921 to 1933, inclusive, when observations were more plentiful. As indicated in the table, no data are available for 11 scattered months, during the period covered. Interpolated values have been used for these months in computing means.

Monthly and annual mean sea-surface temperatures in the extreme Southeastern Gulf of Mexico, 1912 to 1933, inclusive

| Year                        | Total number of observations for the year | January          | February         | March | April | May              | June | July | August | September        | October | November         | December | Annual <sup>1</sup> |
|-----------------------------|---|------------------|------------------|-------|-------|------------------|------|------|--------|------------------|---------|------------------|----------|---------------------|
| 1912                        | 79  | 78               | 75               | 78    | 77    | 81               | 81   | 82   | 84     | 82               | 83      | 79               | 77       | 79.7                |
| 1913                        | 90  | 78               | 74               | 78    | 77    | 78               | 80   | 82   | 82     | 81               | 80      | 78               | 76       | 78.8                |
| 1914                        | 38  | 77               | 78               | 74    | 79    | 77               | 82   | 85   | 85     | 85               | 82      | ( <sup>2</sup> ) | 78       | 80.2                |
| 1915                        | 31  | 78               | 77               | 76    | 78    | 80               | 82   | 85   | 85     | 81               | 83      | 80               | 79       | 80.2                |
| 1916                        | 18  | 79               | 76               | 80    | 77    | ( <sup>2</sup> ) | 84   | 82   | 82     | 82               | 82      | ( <sup>2</sup> ) | 77       | 80.2                |
| 1917                        | 24  | 75               | 77               | 77    | 78    | 81               | 82   | 83   | 86     | ( <sup>2</sup> ) | 80      | ( <sup>2</sup> ) | 74       | 78.5                |
| 1918                        | 14  | 75               | ( <sup>2</sup> ) | 78    | 78    | 81               | 82   | 83   | 86     | 81               | 81      | 81               | 79       | 80.1                |
| 1919                        | 30  | ( <sup>2</sup> ) | ( <sup>2</sup> ) | 78    | 78    | 80               | 81   | 83   | 86     | 81               | 81      | 81               | 79       | 80.1                |
| 1920                        | 76  | 76               | 74               | 79    | 80    | 80               | 82   | 82   | 83     | 83               | 80      | 79               | 78       | 79.7                |
| 1921                        | 115                                       | 76.7             | 74.4             | 76.6  | 77.8  | 181.0            | 82.7 | 82.3 | 82.8   | 82.2             | 79.7    | 78.4             | 76.4     | 80.1                |
| 1922                        | 154                                       | 77.3             | 77.7             | 77.7  | 77.7  | 80.6             | 81.7 | 82.3 | 82.0   | 82.6             | 80.9    | 77.7             | 77.7     | 80.1                |
| 1923                        | 117                                       | 76.5             | 76.7             | 76.0  | 77.4  | 78.6             | 82.0 | 82.4 | 83.8   | 83.4             | 81.4    | 77.2             | 79.0     | 79.5                |
| 1924                        | 116                                       | 76.7             | 76.2             | 77.0  | 79.1  | 80.9             | 83.3 | 84.4 | 84.4   | 84.4             | 81.8    | 76.8             | 76.8     | 80.1                |
| 1925                        | 133                                       | 77.0             | 76.0             | 77.8  | 78.8  | 179.4            | 81.3 | 82.3 | 83.3   | 83.3             | 82.8    | 80.0             | 80.0     | 80.5                |
| 1926                        | 113                                       | 76.5             | 76.0             | 77.1  | 79.1  | 80.8             | 81.8 | 82.4 | 83.4   | 83.4             | 81.4    | 77.2             | 79.0     | 81.0                |
| 1927                        | 115                                       | 78.3             | 78.0             | 78.9  | 79.9  | 80.2             | 83.3 | 84.4 | 84.4   | 84.4             | 83.3    | 78.0             | 79.1     | 81.0                |
| 1928                        | 141                                       | 77.1             | 76.8             | 77.1  | 78.1  | 78.1             | 82.4 | 83.3 | 83.3   | 83.3             | 82.2    | 80.0             | 80.0     | 80.0                |
| 1929                        | 134                                       | 78.0             | 78.3             | 77.7  | 78.8  | 80.0             | 81.3 | 82.0 | 83.3   | 83.3             | 82.2    | 80.0             | 80.0     | 80.2                |
| 1930                        | 125                                       | 78.1             | 77.7             | 77.7  | 78.0  | 78.1             | 81.3 | 82.4 | 83.3   | 83.3             | 82.2    | 80.0             | 80.0     | 80.2                |
| 1931                        | 155                                       | 76.3             | 76.6             | 77.7  | 78.0  | 83.3             | 84.4 | 84.4 | 83.3   | 83.3             | 82.2    | 80.0             | 80.0     | 80.4                |
| 1932                        | 101                                       | 79.2             | 78.6             | 76.9  | 79.1  | 79.6             | 82.2 | 84.0 | 83.3   | 83.3             | 82.2    | 80.0             | 80.0     | 80.7                |
| 1933                        | 127                                       | 78.0             | 78.4             | 77.3  | 78.5  | 80.9             | 82.5 | 82.7 | 83.3   | 83.3             | 82.1    | 80.4             | 77.1     | 80.4                |
| Number of years' record     | 21  | 20               | 22               | 22    | 21    | 22               | 21   | 21   | 21     | 21               | 19      | 21               | 22       |                     |
| Mean (1912-33) <sup>1</sup> | 77.3                                      | 76.7             | 77.7             | 78.1  | 79.6  | 81.9             | 83.0 | 83.3 | 83.2   | 82.9             | 80.9    | 78.0             | 78.0     | 80.0                |

<sup>1</sup> All monthly values were carried to 1 decimal place for these means, which, therefore, are not exact means of figures given here.

<sup>2</sup> No data.

<sup>3</sup> Interpolated values are used for missing months.

## OCEAN GALES AND STORMS, JANUARY 1935

| Vessel                        | Voyage               |                  | Position at time of lowest barometer |           | Gale began January— | Time of lowest barometer January— | Gale ended January— | Lowest barometer | Direction of wind when gale began | Direction and force of wind at time of lowest barometer | Direction of wind when gale ended | Direction and highest force of wind | Shifts of wind near time of lowest barometer |
|-------------------------------|----------------------|------------------|--------------------------------------|-----------|---------------------|-----------------------------------|---------------------|------------------|-----------------------------------|---|-----------------------------------|-------------------------------------|--|
|                               | From—                | To—              | Latitude                             | Longitude |                     |                                   |                     |                  |                                   |   |                                   |                                     |  |
| NORTH ATLANTIC OCEAN          |                      |                  |                                      |           |                     |                                   |                     |                  |                                   |   |                                   |                                     |  |
| Jean Jadot, Belg. S. S.       | Antwerp              | New York         | 50 33 N.                             | 28 40 W.  | *31                 | 6a, 1.                            | 1                   | Inches 29.37     | SSW                               | SSE, 9  | S                                 | SSE, 10                             | SSE-S.                                       |
| Alberta, Ital. S. S.          | Gibraltar            | do               | 34 06 N.                             | 34 40 W.  | 1                   | 4p, 1.                            | 1                   | 29.70            | WSW                               | SW, 7   | W                                 | W, 10                               | SW-W-NW.                                     |
| China Arrow, Am. S. S.        | Boston               | Beaumont, Tex.   | 42 10 N.                             | 70 15 W.  | 1                   | do                                | 3                   | 29.27            | SE                                | SW, 9   | SW                                | SW, 10                              | SE-SW-NW.                                    |
| Statendam, Du. S. S.          | La Guayra, Venez.    | New York         | 37 22 N.                             | 73 23 W.  | 1                   | do                                | 1                   | 29.56            | S                                 | NW, 9   | NW                                | NW, 9                               | S-NW.  |
| Otho, Am. S. S.               | Freetown, W. Africa. | Philadelphia     | 34 37 N.                             | 68 30 W.  | 1                   | 5p, 1.                            | 3                   | 29.66            | S                                 | SSW, 10   | NNW                               | SSW, 10                             | S-SSW-W.                                     |
| Minnequa, Am. S. S.           | Copenhagen           | do               | 42 05 N.                             | 64 01 W.  | 1                   | 10p, 1.                           | 3                   | 29.18            | SE                                | SE, 8   | W                                 | W, 10                               | SE-WSW.                                      |
| Syros, Am. S. S.              | Galveston            | Havre            | 39 00 N.                             | 58 00 W.  | 1                   | 5a, 2.                            | 2                   | 29.24            | SSE                               | NW, 10  | NNW                               | SSW, 10                             | SSW-NW-WNW.                                  |
| Silversandal, Br. M. S.       | Gibraltar            | Halifax          | 41 20 N.                             | 55 00 W.  | 3                   | 8a, 2.                            | 3                   | 29.43            | SW                                | S, 3  | NW                                | W, 12                               | None.  |
| Tennessee, Dan. S. S.         | Bremen               | Norfolk          | 43 58 N.                             | 62 14 W.  | 1                   | do                                | 3                   | 29.01            | E                                 | WSW, 9  | W                                 | W, 11                               | None.  |
| City of Norfolk, Am. S. S.    | Havre                | do               | 42 06 N.                             | 56 20 W.  | 2                   | 2p, 2.                            | 3                   | 29.22            | WNW                               | WSW, 6  | W                                 | NW, 10                              | SSE-WSW-WNW.                                 |
| Steel Trader, Am. S. S.       | Avonmouth            | Newport News     | 36 20 N.                             | 53 30 W.  | 2                   | 7p, 2.                            | 3                   | 29.65            | SW                                | SW, 11  | W                                 | WNW, 12                             | SW-WNW.                                      |
| Emanuel Nobel, Belg. S. S.    | Antwerp              | New York         | 40 26 N.                             | 50 37 W.  | 2                   | Mdt, 2.                           | 3                   | 29.36            | S                                 | WNW, 10   | NW                                | WNW, 10                             | S-WNW-NW.                                    |
| China Arrow, Am. S. S.        | Boston               | Beaumont, Tex.   | 39 00 N.                             | 71 30 W.  | 3                   | 4p, 3.                            | 3                   | 29.83            | SW                                | SW, 9   | N                                 | W, 9                                | SW-N.  |
| Jean Jadot, Belg. S. S.       | Antwerp              | New York         | 46 50 N.                             | 51 12 W.  | 4                   | 11p, 4.                           | 5                   | 29.74            | S                                 | SW, 8   | NW                                | WNW, 9                              | S-SW-W.                                      |
| Bockenheim, Ger. S. S.        | Hoernefors, Sweden.  | Portland, Maine  | 58 00 N.                             | 20 10 W.  | 8                   | 11p, 8.                           | 13                  | 29.23            | W                                 | WSW, 10   | SW                                | WSW, 10                             | WSW-W.                                       |
| Leerdam, Du. S. S.            | Rotterdam            | New York         | 49 18 N.                             | 32 55 W.  | 10                  | 10a, 10.                          | 10                  | 29.84            | WSW                               | WSW, 9  | WNW                               | WSW, 9                              | WSW-WNW.                                     |
| Fairfield City, Am. S. S.     | Cristobal            | Liverpool        | 39 23 N.                             | 61 48 W.  | 10                  | 3a, 11.                           | 12                  | 29.44            | SE                                | SSW, 9  | N                                 | SW, 10                              | S-SSW-SW.                                    |
| Beemsterdijk, Du. S. S.       | New Orleans          | Rotterdam        | 39 47 N.                             | 49 30 W.  | 10                  | 1a, 13.                           | 13                  | 29.46            | SE                                | S, 10   | N                                 | NW, 10                              | S-NW-N.                                      |
| Jean Jadot, Belg. S. S.       | New York             | Antwerp          | 40 20 N.                             | 67 50 W.  | 14                  | 2p, 14.                           | 15                  | 29.19            | WNW                               | WNW, 8  | NW                                | NNW, 9                              | NW-WNW-NNW.                                  |
| Bockenheim, Ger. S. S.        | Hoernefors, Sweden.  | Portland, Maine  | 53 00 N.                             | 38 00 W.  | 13                  | 6p, 14.                           | 15                  | 28.70            | S                                 | WNW, 9  | W                                 | WSW, 9                              | SSE-WNW.                                     |
| Cranford, Am. S. S.           | Bremen               | Norfolk          | 36 55 N.                             | 58 14 W.  | 14                  | do                                | 15                  | 29.25            | SSW                               | SW, 9   | WNW                               | SW, 9                               | SSW-SW-W.                                    |
| Leerdam, Du. S. S.            | Rotterdam            | New York         | 42 50 N.                             | 61 40 W.  | 14                  | 14, 14.                           | 15                  | 28.45            | S                                 | SSW, 8  | NW                                | NNW, 10                             | SSW-W.                                       |
| Malden Creek, Am. S. S.       | Mobile               | London           | 41 40 N.                             | 50 19 W.  | 14                  | 3a, 15.                           | 15                  | 28.93            | S                                 | SSW, 8  | WSW                               | SW, 11                              | S-SW.  |
| Kambove, Belg. S. S.          | Antwerp              | New York         | 41 54 N.                             | 52 00 W.  | 14                  | 4a, 15.                           | 15                  | 28.72            | S                                 | W, 8  | W                                 | SSW, 10                             | SSW-W.                                       |
| Marie Leonhardt, Ger. S. S.   | Rotterdam            | Searsport, Maine | 46 17 N.                             | 53 47 W.  | 12                  | 8a, 15.                           | 16                  | 28.53            | SSW                               | SSE, 9  | NW                                | W, 10                               | SSW-W.                                       |
| Wildwood, Am. S. S.           | Hamburg              | Charleston       | 39 23 N.                             | 47 50 W.  | 14                  | 8p, 15.                           | 15                  | 29.37            | SW                                | SW, 10  | W                                 | SW, 10                              | S-SW-W.                                      |
| Bockenheim, Ger. S. S.        | Hoernefors, Sweden.  | Portland, Maine  | 51 50 N.                             | 42 36 W.  | 15                  | 11p, 15.                          | 16                  | 28.86            | SSE                               | S, 10   | WNW                               | SSE, 11                             | SSE-SSW.                                     |
| H. M. Storey, Am. S. S.       | Colon                | Tiverton, R. I.  | 38 30 N.                             | 71 50 W.  | 16                  | 16, 16.                           | 17                  | 29.63            | SW                                | SE, 8   | SE                                | WSW, 9                              | NW-SE.                                       |
| Djambi, Du. M. S.             | Gibraltar            | Boston           | 41 46 N.                             | 62 27 W.  | 17                  | 4a, 18.                           | 18                  | 29.19            | ESE                               | ESE, 9  | NW                                | ESE, 11                             | ESE-WSW-W.                                   |
| Antinous, Am. S. S.           | Mobile               | Havre            | 46 16 N.                             | 37 12 W.  | 18                  | 4p, 18.                           | 18                  | 29.15            | NNW                               | SSW, 10   | W                                 | SSW, 10                             | SSW-W.                                       |
| Independence Hall, Am. S. S.  | Bordeaux             | New York         | 42 25 N.                             | 60 12 W.  | 18                  | do                                | 19                  | 28.88            | SE                                | W, 5  | NNW                               | SE, 10                              | SW-W-N.                                      |
| Exeter, Am. S. S.             | Gibraltar            | New York         | 42 49 N.                             | 55 30 W.  | 18                  | Mdt, 18.                          | 19                  | 29.16            | E                                 | ENE, 8  | N                                 | N, 9                                | E-ENE-N.                                     |
| Wildwood, Am. S. S.           | Hamburg              | Charleston       | 34 41 N.                             | 56 04 W.  | 17                  | 5a, 19.                           | 19                  | 29.50            | NW                                | W, 10   | NNW                               | W, 10                               | SSW-W-NW.                                    |
| Muncaster Castle, Br. M. S.   | Gibraltar            | New York         | 35 26 N.                             | 42 00 W.  | 19                  | 10a, 19.                          | 19                  | 29.58            | SSW                               | SW, 9   | WNW                               | SW, 10                              | SSW-SW-WNW.                                  |
| Jean Jadot, Belg. S. S.       | New York             | Antwerp          | 46 18 N.                             | 36 45 W.  | 19                  | Noon, 19.                         | 20                  | 29.51            | SSE                               | SSE, 8  | SSE                               | SSE, 10                             | None.  |
| Schoharie, Am. S. S.          | Antwerp              | Charleston       | 37 00 N.                             | 45 05 W.  | 16                  | 4p, 19.                           | 20                  | 29.17            | SSE                               | SW, 8   | N                                 | SSW, 10                             | Steady.                                      |
| Lara, Am. S. S.               | Maracaibo            | La Guayra        | 11 17 N.                             | 71 39 W.  | 19                  | do                                | 19                  | 29.75            | NE                                | NE, 7   | NE                                | NE, 7                               | None.  |
| General Gassouin, Fr. M. S.   | Gibraltar            | Baytown, Tex.    | 31 45 N.                             | 43 20 W.  | 19                  | Mdt, 19.                          | 19                  | 29.51            | SSW                               | W, 7  | WSW                               | SW, 10                              | SW-W.  |
| Kinai Maru, Jap. M. S.        | New York             | Cristobal        | 10 00 N.                             | 79 29 W.  | 20                  | 7a, 21.                           | 21                  | 30.00            | NE                                | NE, 7   | NE                                | NE, 7                               | None.  |
| Valrossa, Ital. S. S.         | Huelva               | New York         | 33 35 N.                             | 44 22 W.  | 22                  | 1p, 22.                           | 22                  | 29.47            | N                                 | N, 11   | N                                 | N, 12                               | Steady.                                      |
| Zarembo, Am. S. S.            | St. Vincent          | do               | 22 06 N.                             | 35 32 W.  | 22                  | 4p, 22.                           | 22                  | 29.74            | SSE                               | WSW, 3  | SSW                               | SSE, 9                              | SSE-WSW.                                     |
| E. J. Sadler, Am. S. S.       | New York             | Baton Rouge      | 28 10 N.                             | 87 58 W.  | 22                  | 6p, 22.                           | 22                  | 29.94            | WNW                               | WNW, 7  | WNW                               | WNW, 9                              | Steady.                                      |
| Ajax, Du. S. S.               | Puerto Barrios       | Amsterdam        | 12 32 N.                             | 50 45 W.  | 23                  | 3p, 23.                           | 23                  | 29.69            | NNE                               | NNE, 9  | ENE                               | NNE, 9                              | NNE-ENE.                                     |
| Western Prince, Br. M. S.     | Trinidad             | New York         | 38 27 N.                             | 72 35 W.  | 23                  | 4p, 23.                           | 24                  | 29.48            | NE                                | ENE, 7  | NNE                               | NNE, 11                             | S-ENE-NNE.                                   |
| Kentuckian, Am. S. S.         | New York             | Cristobal        | 30 48 N.                             | 74 05 W.  | 23                  | do                                | 24                  | 29.74            | SW                                | SW, 8   | NW                                | W, 10                               | S-SW-W.                                      |
| General Gassouin, Fr. M. S.   | Gibraltar            | Baytown, Tex.    | 28 34 N.                             | 55 18 W.  | 22                  | 5p, 23.                           | 23                  | 29.65            | N                                 | N, 9  | NNE                               | N, 9                                | N-NNE.                                       |
| Queen of Bermuda, Br. S. S.   | Nassau, Bahamas.     | New York         | 37 30 N.                             | 74 18 W.  | 23                  | 7p, 23.                           | 24                  | do               | N                                 | NNE, 9  | NNW                               | NNE, 9                              | WSW-NNE-N.                                   |
| Europa, Ger. S. S.            | Cherbourg            | do               | 40 34 N.                             | 69 37 W.  | 24                  | 6a, 24.                           | 24                  | 29.19            | N                                 | N, 11   | N                                 | N, 11                               | None.  |
| Muncaster Castle, Br. M. S.   | Gibraltar            | do               | 35 15 N.                             | 66 52 W.  | 24                  | 10a, 24.                          | 24                  | 29.88            | SW                                | SW, 9   | N                                 | SW, 9                               | SW-N.  |
| Sagaporaack, Am. S. S.        | Copenhagen           | New London       | 58 25 N.                             | 13 20 W.  | 23                  | 25, 25.                           | 25                  | 29.02            | WSW                               | W, 8  | N                                 | NW, 9                               | W-NW.  |
| Pres. Harding, Am. S. S.      | Southampton          | Cobb             | 50 08 N.                             | 3 25 W.   | 25                  | 4p, 25.                           | 26                  | 29.45            | W                                 | W, 9  | N                                 | NNW, 10                             | None.  |
| City of Bagdad, Br. S. S.     | North Shields        | St. John, N. B.  | 56 20 N.                             | 1 40 W.   | 25                  | 8p, 25.                           | 26                  | 28.74            | N                                 | N, 10   | NW                                | N, 10                               | N-NW.  |
| Mahagi, Belg. S. S.           | Tenerife             | Rotterdam        | 46 50 N.                             | 7 03 W.   | 25                  | 5a, 26.                           | 26                  | 29.90            | WNW                               | NW, 9   | N                                 | NW, 10                              | WNW-WNW.                                     |
| City of Bagdad, Br. S. S.     | North Shields        | St. John, N. B.  | 55 22 N.                             | 32 00 W.  | 31                  | 7a, 31.                           | *1                  | 29.54            | SSW                               | SSW, 8  | SW                                | SSW, 9                              | SSW-SW.                                      |
| NORTH PACIFIC OCEAN           |                      |                  |                                      |           |                     |                                   |                     |                  |                                   |   |                                   |                                     |  |
| Shelton, Am. S. S.            | Seattle              | Yokohama         | 47 42 N.                             | 165 30 E. | *31                 | *11p, 31.                         | 1                   | 28.43            | E                                 | NNW, 8  | WNW                               | NW, 11                              | SE-ENE-NNW.                                  |
| Olympia, Am. S. S.            | Tacoma               | do               | 50 55 N.                             | 179 10 W. | *31                 | *10p, 31.                         | 2                   | 28.57            | SE                                | SSW, 10   | WSW                               | W, 12                               | S-SSW-SW.                                    |
| Brightstar, Br. S. S.         | Milke, Japan         | Vancouver, B. C. | 37 12 N.                             | 144 02 E. | *31                 | 1p, 1.                            | 2                   | 29.01            | S                                 | NNW, 8  | NNW                               | NNW, 12                             | SE-NNW.                                      |
| Pres. Jefferson, Am. S. S.    | Yokohama             | Victoria, B. C.  | 36 33 N.                             | 143 48 E. | *31                 | 2p, 1.                            | 2                   | 29.10            | SE                                | NNW, 10   | N                                 | WNW, 12                             | SW - NNW - NW.                               |
| New York, Am. S. S.           | do                   | San Francisco    | 37 40 N.                             | 147 15 E. | 1                   | 8p, 1.                            | 2                   | 29.05            | ESE                               | NE, 12  | NNE                               | NE, 12                              | ESE-NE-N.                                    |
| Gen. M. H. Sherman, Am. S. S. | Los Angeles          | Honolulu         | 29 54 N.                             | 135 00 W. | 1                   | 3a, 2.                            | 1                   | 29.66            | SSE                               | SW, 4   | S                                 | SSE, 8                              | SSE-SW.                                      |
| Golden Horn, Am. S. S.        | San Francisco        | Yokohama         | 32 24 N.                             | 135 06 W. | 2                   | 3p, 2.                            | 3                   | 29.57            | W                                 | WSW, 6  | NNW                               | WNW, 8                              | SW-WSW-W.                                    |
| Golden Star, Am. S. S.        | Yokohama             | San Francisco    | 41 18 N.                             | 163 30 E. | 2                   | 9p, 2.                            | 3                   | 28.63            | E                                 | SW, 4   | W                                 | NW, 11                              | S-SW-NW.                                     |
| Hakubasan Maru, Jap. M. S.    | do                   | Los Angeles      | 39 44 N.                             | 173 38 E. | 3                   | 4a, 3.                            | 3                   | 29.04            | SE                                | SSE, 9  | SW                                | SSE, 9                              | SE-SSE-SW.                                   |
| Shelton, Am. S. S.            | Seattle              | Yokohama         | 46 01 N.                             | 159 19 E. | 3                   | do                                | 3                   | 29.38            | N                                 | N, 8  | NW                                | NNW, 10                             | NW-N-NW.                                     |
| San Clemente, Am. S. S.       | Balboa               | San Diego        | 15 48 N.                             | 94 48 W.  | 3                   | 6a, 3.                            | 3                   | 30.01            | N                                 | N, 8  | NNW                               | N, 8                                | None.  |
| Hiye Maru, Jap. M. S.         | Yokohama             | Vancouver        | 45 13 N.                             | 164 17 E. | 2                   | Noon, 3.                          | 4                   | 29.00            | NE                                | NW, 9   | W                                 | N, 10                               | None.  |
| Empress of Asia, Br. S. S.    | Vancouver            | Yokohama         | 51 28 N.                             | 173 30 W. | 3                   | 2p, 3.                            | 5                   | 28.89            | S                                 | SW, 9   | W                                 | SW, 10                              | S-SW.  |
| Olympia, Am. S. S.            | Tacoma               | do               | 50 15 N.                             | 174 48 E. | 3                   | 2a, 4.                            | 5                   | 28.19            | E                                 | WSW, 8  | W                                 | W, 11                               | SE-WSW-W.                                    |
| Shelton, Am. S. S.            | Seattle              | do               | 43 52 N.                             | 154 48 E. | 5                   | 8a, 5.                            | 6                   | 29.18            | SE                                | SSE, 10   | W                                 | SSE, 10                             | SE-SSE-WSW.                                  |
| Golden Star, Am. S. S.        | Yokohama             | San Francisco    | 44 42 N.                             | 167 18 W. | 7                   | 4p, 7.                            | 7                   | 29.71            | S                                 | S, 9  | SW                                | S, 9                                | S-SW.  |
| Olympia, Am. S. S.            | Tacoma               | Yokohama         | 47 22 N.                             | 159 18 E. | 9                   | 2p, 9.                            | 10                  | 29.13            | W                                 | WSW, 7  | W                                 | W, 9                                | SSE-WSW-W.                                   |
| Bellingham, Am. S. S.         | Dairen               | Vancouver        | 47 40 N.                             | 162 07 E. | 9                   | Noon, 10                          | 11                  | 29.28            | W                                 | W, 8  | W                                 | W, 9                                | Steady.                                      |

\* Position approximate.

\* Barometer uncorrected.

\* December.

## OCEAN GALES AND STORMS, JANUARY 1935—Continued

| Vessel                         | Voyage          |                 | Position at time of lowest barometer |           | Gale began January— | Time of lowest barometer January— | Gale ended January— | Lowest barometer | Direction of wind when gale began | Direction and force of wind at time of lowest barometer | Direction of wind when gale ended | Direction and highest force of wind | Shifts of wind near time of lowest barometer |
|--------------------------------|-----------------|-----------------|--------------------------------------|-----------|---------------------|-----------------------------------|---------------------|------------------|-----------------------------------|---|-----------------------------------|-------------------------------------|--|
|                                | From—           | To—             | Latitude                             | Longitude |                     |                                   |                     |                  |                                   |   |                                   |                                     |  |
| NORTH PACIFIC OCEAN            |                 |                 |                                      |           |                     |                                   |                     |                  |                                   |   |                                   |                                     |  |
| Yeiyo Maru, Jap. S. S.         | Los Angeles     | Tokuyama        | 33 11 N.                             | 154 33 E. | 11                  | 4p, 11                            | 11                  | 29.26            | WSW                               | SW, 7   | WNW                               | W, 9                                | SW - WSW - WNW.                              |
| Tahchee, Br. S. S.             | Yokohama        | Los Angeles     | 39 00 N.                             | 162 30 E. | 11                  | 2p, 12                            | 13                  | 28.76            | E                                 | Var. 3  | WNW                               | WNW, 11                             | ESE-E-NW                                     |
| Olympia, Am. S. S.             | Tacoma          | Yokohama        | 46 35 N.                             | 154 32 E. | 11                  | Mdt, 11                           | 14                  | 29.36            | S                                 | S, 8  | NW                                | NW, 9                               | SSE-S-WSW.                                   |
| Golden Hind, Am. S. S.         | Tsingtau        | San Francisco   | 44 17 N.                             | 163 12 E. | 13                  | 6p, 13                            | 15                  | 28.59            | W                                 | W, 12   | SW                                | W, 12                               | NW-W.  |
| City of Victoria, Br. S. S.    | Dairen          | Vancouver       | 45 02 N.                             | 154 02 E. | 12                  | Noon, 14                          | 15                  | 28.89            | NNW                               | NW, 8   | WNW                               | NW, 9                               | NNW-NW.                                      |
| Pres. Grant, Am. S. S.         | Seattle         | Yokohama        | 47 01 N.                             | 163 30 E. | 13                  | 4a, 14                            | 15                  | 28.08            | ESE                               | NW, 5   | NW                                | E, 11                               | NE-NW.                                       |
| Pres. Jackson, Am. S. S.       | Yokohama        | Victoria, B. C. | 42 20 N.                             | 157 10 E. | 13                  | 6a, 15                            | 16                  | 29.52            | N                                 | WNW, 9  | WNW                               | W, 10                               |  |
| Mala, Am. S. S.                | New Westminster | Honolulu        | 47 48 N.                             | 126 06 W. | 16                  | 3p, 16                            | 17                  | 29.38            | W                                 | W, 7  | WNW                               | W, 8                                | None.  |
| Michigan, Am. S. S.            | Otaru, Japan    | San Francisco   | 44 38 N.                             | 150 05 E. | 16                  | 2p, 17                            | 18                  | 28.59            | NE                                | NNE, 8  | W                                 | NE, 9                               | NE-N.  |
| Seattle, Am. S. S.             | Seattle         | Yokohama        | 50 01 N.                             | 178 35 E. | 17                  | 4a, 19                            | 19                  | 29.37            | SSE                               | S, 8  | S                                 | SSE, 9                              | SSE-S-WSW.                                   |
| Michigan, Am. S. S.            | Otaru, Japan    | San Francisco   | 48 07 N.                             | 162 52 E. | 19                  | 10p, 19                           | 21                  | 28.16            | NE                                | SE, 11  | SSW                               | SE, 11                              | E-SE-S.                                      |
| Seattle, Am. S. S.             | Seattle         | Yokohama        | 49 06 N.                             | 172 45 E. | 20                  | 2p, 20                            | 20                  | 28.88            | E                                 | E, 8  | SW                                | WSW, 9                              | ESE-E-WSW.                                   |
| Kentucky, Am. S. S.            | Dairen          | Los Angeles     | 41 17 N.                             | 158 50 E. | 19                  | Noon, 19                          | 22                  | 29.22            | N                                 | N, 8  | NNW                               | NW, 9                               | NNE-N-NW.                                    |
| Gen. M. H. Sherman, Am. S. S.  | Hilo, Hawaii    | do              | 28 18 N.                             | 138 06 W. | 20                  | 3a, 21                            | 20                  | 29.80            | SSE                               | SSE, 7  | SSE                               | SSE, 8                              | SSE-S.                                       |
| Astoria, Am. S. S.             | San Francisco   | Portland, Oreg. | 44 06 N.                             | 124 24 W. | 21                  | 4p, 21                            | 21                  | 30.06            | SE                                | SSE, 9  | SSE                               | SSE, 9                              | SE-SSE.                                      |
| Georgian, Am. S. S.            | Los Angeles     | Balboa          | 13 55 N.                             | 95 55 W.  | 22                  | 7a, 22                            | 23                  | 29.94            | NNE                               | NNE, 10   | N                                 | NNE, 10                             | NNE-N.                                       |
| Juyo Maru, Jap. S. S.          | Muroran         | Coos Bay, Oreg. | 42 22 N.                             | 141 01 E. | 22                  | 6a, 22                            | 24                  | 29.10            | NW                                | NW, 5   | WNW                               | WNW, 9                              | SW-NW.                                       |
| Malolo, Am. S. S.              | Los Angeles     | Honolulu        | 25 50 N.                             | 147 24 W. | 23                  | 5a, 23                            | 23                  | 29.55            | S                                 | SW, 8   | WSW                               | WSW, 8                              | S-SW-W.                                      |
| Mariposa, Am. S. S.            | Honolulu        | Los Angeles     | 25 45 N.                             | 145 40 W. | 23                  | 6a, 23                            | 23                  | 29.60            | S                                 | S, 7  | S                                 | S, 8                                | None.  |
| Heian Maru, Jap. M. S.         | Yokohama        | Vancouver       | 38 54 N.                             | 146 54 E. | 23                  | 10p, 23                           | 24                  | 29.51            | W                                 | W, 9  | W                                 | W, 9                                |  |
| Soyo Maru, Jap. M. S.          | Los Angeles     | Balboa          | 14 35 N.                             | 95 53 W.  | 23                  | 4p, 23                            | 24                  | 29.88            | NE                                | NE, 6   | NNW                               | NNE, 8                              | ENE-NE-N.                                    |
| Santos Maru, Jap. M. S.        | Balboa          | Los Angeles     | 14 23 N.                             | 94 33 W.  | 23                  | Mdt, 23                           | 24                  | 29.92            | NE                                | N, 7  | N                                 | NE, 9                               | NE-N.  |
| Everett, Am. S. S.             | Manila          | do              | 35 00 N.                             | 170 42 W. | 27                  | 1p, 27                            | 27                  | 29.06            | W                                 | WNW, 10   | NW                                | WNW, 10                             |  |
| Hauraki, Br. M. S.             | Samoa           | Vancouver       | 36 54 N.                             | 139 19 W. | 27                  | 4p, 27                            | 28                  | 29.26            | S                                 | S, 8  | SW                                | SW, 9                               | S-SW.  |
| Susan V. Luckenbach, Am. S. S. | Balboa          | Los Angeles     | 14 27 N.                             | 96 27 W.  | 27                  | 4a, 28                            | 28                  | 30.18            | NNE                               | NE, 7   | NE                                | NE, 8                               | Steady.                                      |
| Maliko, Am. S. S.              | San Francisco   | Honolulu        | 28 30 N.                             | 145 30 W. | 28                  | 10a, 28                           | 28                  | 29.54            | SW                                | SW, 8   | WSW                               | WSW, 10                             | SW-WSW.                                      |
| Tosari, Du. M. S.              | Manila          | Los Angeles     | 32 58 N.                             | 154 43 W. | 28                  | 4a, 27                            | 30                  | 29.09            | WSW                               | WSW, 6  | S                                 | WSW, 10                             | WSW-W.                                       |
| Asama Maru, Jap. M. S.         | Honolulu        | San Francisco   | 29 06 N.                             | 144 32 W. | 28                  | Noon, 28                          | 29                  | 29.57            | W                                 | W, 7  | W                                 | W, 8                                | SSW-W.                                       |
| Hauraki, Br. M. S.             | Samoa           | Vancouver       | 41 27 N.                             | 134 30 W. | 28                  | Mdt, 28                           | 30                  | 28.96            | SE                                | SE, 9   | SSE                               | SSE, 11                             | SE-SSE.                                      |
| City of Victoria, Br. S. S.    | Dairen          | do              | 49 14 N.                             | 138 26 W. | 29                  | 7a, 29                            | 29                  | 28.30            | NE                                | ESE, 7  | SSE                               | SE, 10                              | NE-SE.                                       |
| Michigan, Am. S. S.            | Otaru, Japan    | San Francisco   | 46 44 N.                             | 145 41 W. | 29                  | Noon, 29                          | 29                  | 28.48            | NNW                               | NW, 9   | W                                 | NW, 9                               | N-NW-W.                                      |
| City of Elwood, Am. M. S.      | Balboa          | Los Angeles     | 13 50 N.                             | 95 15 W.  | 30                  | 5a, 30                            | 30                  | 29.97            | N                                 | N, 8  | NNE                               | N, 8                                | N-NNE.                                       |
| Maliko, Am. S. S.              | San Francisco   | Honolulu        | 25 34 N.                             | 150 58 W. | 29                  | 8a, 30                            | 30                  | 29.65            | SW                                | S, 7  | NW                                | SW, 9                               | S-SW.  |
| City of Victoria, Br. S. S.    | Dairen          | Vancouver       | 49 18 N.                             | 131 51 W. | 31                  | 4a, 31                            | 31                  | 29.34            | SE                                | SE, 7   | SE                                | SE, 8                               |  |
| Maliko, Am. S. S.              | San Francisco   | Honolulu        | 22 36 N.                             | 155 30 W. | 31                  | 2p, 31                            | 31                  | 29.72            | WNW                               | WSW, 8  | WSW                               | WSW, 8                              |  |
| Jeff Davis, Am. M. S.          | Kelung, Formosa | Los Angeles     | 33 59 N.                             | 145 58 E. | 31                  | 8a, 31                            | **1                 | 29.45            | SSW                               | SSW, 8  | NW                                | WNW, 10                             | SSW-W.                                       |
| San Diego Maru, Jap. M. S.     | Kobe            | do              | 37 10 N.                             | 149 51 E. | 31                  | 4p, 31                            | **1                 | 28.90            | SSE                               | WSW, 10   | NW                                | W, 10                               | SSE-WSW-W.                                   |
| Tatsuno Maru, Jap. S. S.       | Otaru, Japan    | do              | 42 18 N.                             | 160 46 E. | 31                  | 8a, 1*                            | **1                 | 28.67            | ESE                               | ENE, 3  | NNW                               | ESE, 9                              | ESE - ENE - NNW.                             |

\* Position approximate.

\* Barometer uncorrected.

\*\* February

## NORTH PACIFIC OCEAN, JANUARY 1935

By WILLIS E. HURD

**Atmospheric pressure.**—The pressure situation on the North Pacific during January 1935 was in some respects unusual. On the average the entire Aleutian region and a huge area of the sea to the southward was dominated by cyclonic activity. At the Alaskan island stations the barometer was about 0.1 inch above the normal, while at Midway Island and Honolulu, it was about the same amount below, thus indicating the south-reaching effect of the great mid-ocean cyclones. The longitudinal extent of the depressed region was ocean wide, particularly between 40° and 50° north latitude, where abnormally low pressures extended from coast to coast.

The anticyclone off the California coast was much restricted in area and extended southwestward only about half the distance to the Hawaiian Islands.

In Asiatic waters the effects of the continental anticyclone extended eastward to the Ogasawara Islands and southward to the Philippines. The result was that at Manila the average pressure, 29.94 inches, was 0.05 above the normal. At Guam, where the normal winter pressure is practically the same as that at Manila, the January average in 1935 was 29.83 inches, or 0.11 inch lower than at Manila.

TABLE 1.—Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, January 1935, at selected stations

| Stations       | Average pressure | Departure from normal | Highest | Date   | Lowest | Date |
|----------------|------------------|-----------------------|---------|--------|--------|------|
|                | Inches           | Inch                  | Inches  |        | Inches |      |
| Point Barrow   | 30.17            | +0.09                 | 30.82   | 15, 22 | 28.98  | 9    |
| Dutch Harbor   | 29.66            | +0.08                 | 30.46   | 10     | 28.96  | 4    |
| St. Paul       | 29.65            | +0.02                 | 30.20   | 19     | 28.62  | 4    |
| Kodiak         | 29.68            | +0.09                 | 30.56   | 11     | 28.72  | 27   |
| Juneau         | 29.88            | .00                   | 30.60   | 17     | 29.03  | 5    |
| Tatoosh Island | 29.86            | -.12                  | 30.33   | 20     | 29.29  | 16   |
| San Francisco  | 30.07            | -.04                  | 30.48   | 21     | 29.61  | 9    |
| Mazatlan       | 29.95            | .00                   | 30.04   | 30     | 29.86  | 14   |
| Honolulu       | 29.92            | -.08                  | 30.13   | 6      | 29.68  | 23   |
| Midway Island  | 29.92            | -.11                  | 30.16   | 9      | 29.62  | 10   |
| Guam           | 29.83            | -.07                  | 29.92   | 7, 8   | 29.72  | 29   |
| Manila         | 29.94            | +0.05                 | 30.06   | 25     | 29.82  | 14   |
| Hong Kong      | 30.09            |                       | 30.28   | 24     | 29.87  | 14   |
| Naha           | 30.10            | +0.02                 | 30.32   | 23     | 29.80  | 14   |
| Chichishima    | 30.01            | .00                   | 30.18   | 25     | 29.58  | 15   |
| Nemuro         | 29.86            |                       | 30.24   | 2      | 29.16  | 21   |

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

**Cyclones and gales.**—The western half of the North Pacific was unusually stormy during much of January, and on a third of the days of the month gales of the higher forces (11 to 12) occurred over the region from the central Aleutians southwestward to Japan, and as far south—

between 140° and 170° E.—as approximately the 35th parallel.

Over the central part of the ocean, while low pressure prevailed and the weather was unsettled, gales were far less frequent and severe.

Toward the American coast storminess increased, and there was an unusual prevalence of gales along the west coast—Hawaiian routes. In only one instance in these waters, however, was there report of a velocity exceeding force 10.

While in the previous December it was observed that an unusually small number of Asiatic continental cyclones entered upon the ocean, this was not the case in January, since a number of middle and high latitude storms in far eastern waters were of land origin.

The month opened with intense cyclonic activity disturbing much of the western half of the northern steamship route. Between Honshu, Japan, and longitude 150° E., hurricane velocities, with pressures close to 29 inches, occurred on the 1st, while gales of force 11–12 were simultaneously experienced by ships south of the central Aleutians and also midway between that point and northern Japan, with central pressures well below 29 inches. Heavy gales continued over most of the region through the 4th, moderating on the 5th, although even on that date one encounter with a whole gale was reported by a ship southeast of the Kuril Islands. On the 2d and 3d, the American S. S. *Golden Star* reported a force of 11 near 41° N., 163° E. On the 4th the American S. S. *Olympia* read the lowest pressure of the period—28.19 inches—near 50° N., 175° E., accompanied by a wind of force 11.

On January 11 two cyclones—one from south of Japan and the other from the neighborhood of Sakhalin Island and the Okhotsk Sea—entered the sea area east of Japan and the Kuril Islands. Thereafter another period of great storm depth and violence ensued over practically the same region as that covered by the gales of the 1st to 5th. The intensity was most strongly concentrated in the area between 35° and 50° N., 160° to 170° E., where winds of force 11 to 12 occurred on the 12th to 14th, accompanied by pressures below 28.50 inches. The American S. S. *Golden Hind*, near 44° N., 163° E., on the 13th, encountered hurricane winds, and in her weather report quoted from a Tokyo storm message of the 15th to the effect that the disturbance moving northeastward, was then central near 50° N., 164° E., lowest pressure of 27.95. The American S. S. *General Grant*, in 47° N., 163½° E., on the 14th, reported an east gale of force 11, lowest pressure 28.08.

Meanwhile a deep Japanese cyclone entered the already disturbed region on the 15th and 16th, and for several days lay to the eastward of the Kuril Islands. The American S. S. *General Lee* encountered winds of hurricane force on the 19th, in connection with it, near 48° N.,

158° E., and on the 20th the American S. S. *Michigan*, about 5° to the eastward, also experienced hurricane velocities, with lowest barometer, 28.16 inches. Storm conditions abated during the 21st.

Toward the end of the month a depression, which originated near Taiwan, moved northeastward and developed sufficiently when near 35° N., 150° E., to cause strong to whole gales in the vicinity.

On the 15th to 18th, during the prevalence of a powerful anticyclone over southeastern Asia and the adjacent waters, a strong northeast monsoon prevailed along the entire east China coast to the Nansei Islands and Luzon.

Over the eastern half of the Pacific, an unusual amount of stormy weather occurred along the west coast routes to the Hawaiian Islands. A moderate cyclone caused gales of force 8–9 midway along the routes on the 1st to 3d, and from the 20th until the end of the month gales of similar force were of almost daily occurrence in the general neighborhood.

About the 15th a moderate Low gathered to the northward of the Hawaiian Islands. It spread rapidly in area until, by the 20th it had covered much of the middle and northern part of the ocean. The central part of this enormous depressed region was not particularly stormy, but along its eastern and southeastern boundaries storm activity was more pronounced. On the 16th and 17th fresh westerly gales blew outside of Cape Flattery, and on the 21st fresh to strong southerly gales disturbed the coastal waters off Washington and Oregon.

On the 21st the Japanese M. S. *Hokuman Maru* was distressed in heavy seas about 500 miles west of Vancouver, and her crew of 45 persons was taken off by the American S. S. *President Jackson*. Up to the end of January search for the abandoned vessel by plane and salvage ship was reported as so hampered by stormy weather, snow, and fog, that further effort in that direction was temporarily discontinued.

During the 27th to 30th winds of considerable violence were reported north of the 35th parallel, between 130° and 145° W., culminating in a southerly gale of force 11, pressure 28.98, experienced by the British M. S. *Hauraki*, near 41½° N., 134½° W.

*Tehuantepecers.*—Norther weather was frequent this month in the Gulf of Tehuantepec, and gales were reported by ships in these waters, as follows: Of force 7 on the 27th and 29th; of force 8 on the 3d, 23d, 25th, 28th, and 30th; of force 9 on the 24th; and of force 10 on the 22d.

*Fog.*—From a meteorological standpoint, the most interesting reports of fog in January of this year were those which showed its occurrence on 4 days in the Gulf of Tehuantepec. Fog was observed off Lower California on 2 days, and off California on 6 days. At some distance off the west coast it was reported on 5 days late in the month.

## CLIMATOLOGICAL TABLES

## DESCRIPTION OF TABLES AND CHARTS

(R. J. Martin)

Table 1 gives the data ordinarily needed for climatological studies for about 180 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m. daily, seventy-fifth meridian time, and for about 23 others making only one observation. The altitudes of the instruments above ground are also given.

Beginning with January 1, 1932, all wind movements and velocities published herein are corrected to true values by applying to the anemometer readings corrections determined by actual tests in wind tunnels and elsewhere.

Table 2 gives, for about 37 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation, depth of snowfall, and the respective departures from normal values except in the case of snowfall. The sea-level pressures have been computed according to the method described by Prof. F. H. Bigelow in the REVIEW of January 1902, 30: 13-16.

CHART I.—*Temperature departures*.—This chart presents the departures of the monthly mean surface temperatures from the monthly normals. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly surface temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July 1909, but smaller charts appear in W. B. Bulletin U for 1873 to June 1909, inclusive.

CHART II.—*Tracks of centers of ANTICYCLONES*; and

CHART III.—*Tracks of centers of CYCLONES*. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month, the location indicated being that at 8 a. m., seventy-fifth meridian time. Within each circle is also an entry of the last three figures of (chart II) the highest barometric reading, or (chart III) the lowest reading reported at or near the center at that time, in both cases as reduced to sea level and standard gravity. The intermediate 8 p. m. locations are indicated by dots. The inset map on chart II shows the departure of monthly mean pressure from normal and the inset on chart III shows the change in mean pressure from the preceding month.

The use of a new base map for charts II and III began with the January 1930 issue.

CHART IV.—*Percentage of clear sky between sunrise and sunset*.—The average cloudiness at each regular Weather Bureau station is determined by numerous personal

observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the night hours.

CHART V.—*Total precipitation*.—The scales of shading with appropriate lines show the distribution of the monthly precipitation according to reports from both regular and cooperative observers. The inset on this chart shows the departure of the monthly totals from the corresponding normals, as indicated by the reports from the regular stations.

CHART VI.—*Isobars at sea level, and isotherms at surface; prevailing winds*.—The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow in the REVIEW for January 1902, 30: 13-16. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, at stations taking but a single observation.

The diurnal corrections so applied, except for stations established since 1901, will be found in the Annual Report of the Chief of the Weather Bureau, 1900-1901, volume 2, table 27, pages 140-164.

The sea-level temperatures are now omitted and average surface temperatures substituted. The isotherms cannot be drawn in such detail as might be desired, for data from only the regular Weather Bureau stations are used.

The prevailing wind directions are determined from hourly observations at almost all the stations. A few stations determine their prevailing directions from the daily or twice-daily observations only.

CHART VII.—*Wind roses for selected stations*.—This is a new chart, beginning with the REVIEW for January 1935, which gives wind roses for 28 selected stations. The roses are based on hourly percentages for the month.

CHART VIII.—*Total snowfall*.—This is based on the reports from regular and cooperative observers and shows the depth in inches of the snowfall during the month. In general, the depth is shown by lines connecting places of equal snowfall, but in special cases figures also are given. This chart is published only when the snowfall is sufficiently extensive to justify its preparation. The inset on this chart, when included, shows the depth of snow on the ground at 8 p. m. of the Monday nearest the end of the month.

CHARTS IX, X, etc.—*North Atlantic weather maps of particular days*.

## CLIMATOLOGICAL TABLES

## CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau, the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

*Condensed climatological summary of temperature and precipitation by sections, January 1935*

| Section           | Temperature             |   |                    |                 |      |                    | Precipitation          |  |                       |        |                   |        |
|-------------------|-------------------------|---|--------------------|-----------------|------|--------------------|------------------------|--|-----------------------|--------|-------------------|--------|
|                   | Section average<br>° F. | Departure<br>from the nor-<br>mal<br>° F. | Monthly extremes   |                 |      |                    | Section average<br>In. | Departure<br>from the nor-<br>mal<br>In. | Greatest monthly      |        | Least monthly     |        |
|                   |                         |   | Station            | Highest<br>° F. | Date | Station            | Lowest<br>° F.         | Date                                     | Station               | Amount | Station           | Amount |
| Alabama           | 48.8                    | +2.4                                      | 5 stations         | 81              | 20   | Madison            | 7                      | 24                                       | Decatur               | 6.38   | Robertsdale       | 0.89   |
| Arizona           | 45.3                    | +1.1                                      | Casa Grande Ruins  | 89              | 29   | Fort Valley        | -17                    | 21                                       | Bright Angel, R. S.   | 5.49   | Gila Bend         | .03    |
| Arkansas          | 43.6                    | +2.2                                      | Camden             | 86              | 16   | Deer               | -11                    | 21                                       | Helena                | 12.51  | Gravette          | 2.48   |
| California        | 43.7                    | -1.1                                      | Tustin (near)      | 89              | 31   | Soda Springs       | -21                    | 19                                       | Inskip                | 14.78  | Greenland Ranch   | .27    |
| Colorado          | 30.1                    | +6.1                                      | Holly              | 75              | 26   | Fraser             | -40                    | 21                                       | Cumbres               | 5.24   | 2 stations        | .00    |
| Florida           | 60.4                    | +1.2                                      | Clermont           | 89              | 18   | Cottage Hill       | 17                     | 23                                       | West Palm Beach       | 6.66   | Everglades        | .00    |
| Georgia           | 49.0                    | +1.8                                      | Alapaha            | 84              | 20   | 3 stations         | 13                     | 24                                       | Flat Top              | 7.85   | Midville          | .92    |
| Idaho             | 25.2                    | +1.2                                      | Glenns Ferry       | 62              | 28   | Alpha              | -41                    | 20                                       | Roland                | 9.85   | Salmon            | .10    |
| Illinois          | 29.2                    | +2.6                                      | Cairo              | 67              | 16   | Freeport           | -16                    | 23                                       | Cairo                 | 4.74   | Clinton           | .97    |
| Indiana           | 31.2                    | +2.1                                      | 2 stations         | 65              | 16   | Valparaiso         | -10                    | 24                                       | Madison               | 5.13   | La Porte          | 1.39   |
| Iowa              | 20.6                    | +1.9                                      | Keokuk             | 58              | 2    | 2 stations         | -30                    | 23                                       | Decorah               | 2.49   | Logan             | .08    |
| Kansas            | 35.0                    | +5.1                                      | Richfield          | 74              | 26   | St. Francis        | -19                    | 21                                       | Coffeyville           | 1.53   | Smith Center      | .00    |
| Kentucky          | 37.3                    | +1.4                                      | 2 stations         | 71              | 7    | 2 stations         | -2                     | 24                                       | Bowling Green         | 9.92   | Carrollton        | 2.79   |
| Louisiana         | 54.2                    | +2.6                                      | Donaldsonville     | 86              | 20   | St. Joseph         | 5                      | 23                                       | Calhoun               | 6.88   | Port Eads         | .21    |
| Maryland-Delaware | 31.4                    | -1.5                                      | Princess Anne, Md. | 71              | 9    | Bell, Md.          | -23                    | 28                                       | Milford, Del.         | 7.59   | Chewsville, Md.   | 2.89   |
| Michigan          | 20.4                    | +4  | 2 stations         | 49              | 17   | Sidnaw             | -40                    | 23                                       | Deer Park             | 5.03   | Howard City       | .75    |
| Minnesota         | 5.1                     | -4.6                                      | Pipestone          | 53              | 2    | Pine River Dam     | -51                    | 23                                       | Pigeon River Bridge   | 3.42   | Artichoke Lake    | .26    |
| Mississippi       | 48.6                    | +1.2                                      | Greenville         | 86              | 20   | 2 stations         | 4                      | 24                                       | Hernando              | 15.20  | Biloxi            | .43    |
| Missouri          | 33.0                    | +2.1                                      | Garber             | 71              | 16   | Conception         | -12                    | 21                                       | Bragg City            | 7.00   | Edgerton          | .50    |
| Montana           | 17.7                    | -2.1                                      | Sun River Canyon   | 67              | 25   | Upper Yaak River   | -48                    | 20                                       | Heron                 | 7.44   | 2 stations        | .02    |
| Nebraska          | 27.1                    | +4.6                                      | McCook             | 72              | 5    | Gordon             | -33                    | 21                                       | Hartington            | .99    | 4 stations        | .00    |
| Nevada            | 32.8                    | +3.3                                      | Logandale          | 79              | 31   | Canyon Creek Ranch | -22                    | 21                                       | Marlette Lake         | 4.27   | Montello          | .30    |
| New England       | 17.5                    | -5.1                                      | Plymouth, Mass.    | 62              | 9    | Pittsburg, N. H.   | -44                    | 31                                       | Portland, Maine       | 12.29  | Burlington, Vt.   | 2.80   |
| New Jersey        | 28.2                    | -2.7                                      | Indian Mills       | 65              | 8    | Runyon             | -26                    | 28                                       | Hammonton             | 5.98   | Boonton           | 2.37   |
| New Mexico        | 37.5                    | +3.7                                      | San Marcial        | 78              | 28   | Selsor Ranch       | -35                    | 21                                       | Jewett Ranger Station | 3.63   | 9 stations        | .00    |
| New York          | 19.8                    | -3.4                                      | Angelica           | 67              | 7    | 2 stations         | -42                    | 27                                       | Greenfield Center     | 6.95   | Dansville         | 1.31   |
| North Carolina    | 41.8                    | +2  | Goldboro           | 80              | 22   | do                 | -1                     | 24                                       | Mount Mitchell        | 8.85   | Mount Gilead      | 1.04   |
| North Dakota      | 3.3                     | -3.3                                      | Mott               | 60              | 30   | Sanish             | -44                    | 23                                       | Howard                | 1.10   | Ashley            | T      |
| Ohio              | 29.9                    | +1.4                                      | Gallipolis (near)  | 74              | 8    | 2 stations         | -10                    | 28                                       | Ironton               | 5.27   | Mt. Vernon (near) | 1.41   |
| Oklahoma          | 42.9                    | +4.5                                      | 3 stations         | 80              | 16   | Boise City         | -7                     | 21                                       | Idabel                | 6.40   | Hollis            | T      |
| Oregon            | 31.8                    | -1  | Sundown Ranch      | 73              | 31   | 2 stations         | -37                    | 20                                       | Seaside               | 15.15  | Umatilla          | .13    |
| Pennsylvania      | 27.5                    | -4  | Donora             | 72              | 21   | Hawley             | -23                    | 28                                       | Johnstown             | 5.08   | Bloersville       | 1.00   |
| South Carolina    | 46.3                    | +4  | 3 stations         | 80              | 121  | 3 stations         | 10                     | 28                                       | Caesars Head          | 8.60   | Orangeburg        | .62    |
| South Dakota      | 17.5                    | +1.3                                      | Hot Springs        | 67              | 29   | McIntosh           | -34                    | 23                                       | Menno                 | .78    | 7 stations        | T      |
| Tennessee         | 40.9                    | +1.6                                      | Milan              | 76              | 13   | 3 stations         | 0                      | 24                                       | Bolivar               | 15.75  | Kingston          | 2.06   |
| Texas             | 52.2                    | +4.0                                      | Hebbronville       | 94              | 17   | Booker             | -6                     | 20                                       | Clarksville           | 7.17   | 9 stations        | .60    |
| Utah              | 30.0                    | +4.7                                      | 2 stations         | 70              | 129  | Thistle            | -29                    | 21                                       | Silver Lake           | 4.14   | Manila            | .00    |
| Virginia          | 35.6                    | -1.0                                      | Diamond Springs    | 78              | 121  | Mineral            | -18                    | 28                                       | Floyd                 | 7.91   | Langley Field     | 2.53   |
| Washington        | 31.8                    | +2.1                                      | 3 stations         | 72              | 31   | 3 stations         | -35                    | 20                                       | Quinalt               | 50.39  | Mottinger         | .11    |
| West Virginia     | 33.3                    | +6  | Ravenswood         | 74              | 9    | McNeill            | -23                    | 25                                       | Alpena                | 7.68   | Marlinton         | 1.82   |
| Wisconsin         | 12.5                    | -2.7                                      | Fond du Lac        | 48              | 6    | Grantsburg         | -50                    | 23                                       | Rhineland             | 3.48   | Plymouth          | .63    |
| Wyoming           | 24.0                    | +3.8                                      | Pine Bluffs        | 68              | 27   | West Yellowstone   | -46                    | 20                                       | Snake River           | 2.94   | 3 stations        | .00    |
| Alaska (December) | 14.2                    | +6.7                                      | Sitka              | 64              | 8    | Allakaket          | -52                    | 31                                       | Cordova               | 30.92  | Shishmaref        | .17    |
| Hawaii            | 68.8                    | +5  | Pahala             | 92              | 23   | Kanaloahulu        | 39                     | 29                                       | Puhonua               | 28.70  | Pahumimi          | 1.08   |
| Puerto Rico       | 71.9                    | -8  | San German         | 91              | 14   | Guineo Reservoir   | 40                     | 27                                       | La Mina               | 9.43   | Sabana Grande     | .00    |

<sup>1</sup> Other dates also

TABLE I.—Climatological data for Weather Bureau stations, January 1935

| District and station   | Elevation of instruments  |                          |                         | Pressure                             |  |                       | Temperature of the air   |                       |         |      |         |      |              |                      |                      |                                   | Precipitation          |       |                       | Wind                    |                |                      |                  |           | Clear days | Partly cloudy days | Cloudy days | Average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |      |      |      |          |  |       |  |     |  |  |  |  |
|------------------------|---------------------------|--------------------------|-------------------------|--------------------------------------|--|-----------------------|--------------------------|-----------------------|---------|------|---------|------|--------------|----------------------|----------------------|-----------------------------------|------------------------|-------|-----------------------|-------------------------|----------------|----------------------|------------------|-----------|------------|--------------------|-------------|----------------------------|----------------|--|------|------|------|----------|--|-------|--|-----|--|--|--|--|
|                        | Barometer above sea level | Thermometer above ground | Anemometer above ground | Station, reduced to mean of 24 hours | Sea level, reduced to mean of 24 hours | Departure from normal | Mean max. + mean min. +2 | Departure from normal | Maximum | Date | Minimum | Date | Mean minimum | Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Total | Departure from normal | Days with 0.01, or more | Total movement | Prevailing direction | Maximum velocity |           |            |                    |             |                            |                |  | Date |      |      |          |  |       |  |     |  |  |  |  |
|                        |                           |                          |                         |                                      |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      | Miles per hour   | Direction |            |                    |             |                            |                |  |      |      |      |          |  |       |  |     |  |  |  |  |
| New England            |                           |                          |                         |                                      |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |           |            |                    |             |                            |                |  | 6.05 |      |      | In. +2.6 |  | Miles |  |     |  |  |  |  |
| Eastport               | 76                        | 67                       | 85                      | 29.98                                | 30.07                                  | +0.07                 | 16.6                     | -3.8                  | 47      | 10   | 25      | -14  | 28           | 8                    | 49                   | 15                                | 12                     | 86    | 7.32                  | +3.4                    | 15             | 10,545               | nw.              | 40        | ne.        | 24                 | 11          | 2                          | 18             | 6.5  | 33.4 | 16.5 |      |          |  |       |  |     |  |  |  |  |
| Greenville, Maine      | 1,070                     | 6                        | 40                      | 28.86                                | 30.10                                  |                       | 7.4                      |                       | 48      | 8    | 17      | -22  | 27           | 2                    | 36                   | 15                                | 10                     | 75    | 6.86                  |                         | 15             | 7,332                | nw.              | 31        |            | 4                  | 12          | 3                          | 16             | 57.5   |      |      |      |          |  |       |  |     |  |  |  |  |
| Portland, Maine        | 103                       | 82                       | 117                     | 29.99                                | 30.12                                  | +0.07                 | 17.9                     | -4.5                  | 46      | 8    | 25      | -11  | 28           | 10                   | 30                   | 15                                | 10                     | 75    | 12.29                 | +8.3                    | 15             | 7,009                | n.               | 30        | ne.        | 24                 | 15          | 4                          | 12             | 4.9  | 59.0 | 27.0 |      |          |  |       |  |     |  |  |  |  |
| Concord                | 289                       | 60                       | 60                      | 29.98                                | 30.16                                  |                       | 17.2                     | -4.4                  | 54      | 8    | 27      | -15  | 28           | 7                    | 34                   |                                   |                        |       | 5.87                  | +2.9                    | 13             |                      | nw.              |           |            | 11                 | 2           | 18                         | 46.7           |  |      |      |      |          |  |       |  |     |  |  |  |  |
| Burlington             | 403                       | 11                       | 48                      | 29.68                                | 30.16                                  | +0.11                 | 12.1                     | -6.7                  | 45      | 7    | 22      | -22  | 31           | 2                    | 34                   |                                   |                        |       | 2.80                  | +1.0                    | 17             | 9,236                | s.               | 40        | s.         | 5                  | 6           | 10                         | 15.6           | 17.6   | 3.7  |      |      |          |  |       |  |     |  |  |  |  |
| Northfield             | 876                       | 12                       | 60                      | 29.15                                | 30.15                                  | +0.10                 | 9.6                      | -5.6                  | 52      | 7    | 22      | -32  | 31           | 3                    | 49                   | 9                                 | 6                      | 86    | 3.94                  | +1.6                    | 17             | 6,193                | n.               | 28        | sw.        | 3                  | 7           | 17                         | 6.6            | 29.5   | 11.4 |      |      |          |  |       |  |     |  |  |  |  |
| Boston                 | 124                       | 336                      | 360                     | 29.98                                | 30.13                                  | +0.08                 | 23.2                     | -4.7                  | 56      | 9    | 32      | -5   | 27           | 18                   | 32                   | 21                                | 14                     | 69    | 6.13                  | +2.5                    | 12             | 11,689               | nw.              | 46        | w.         | 2                  | 12          | 4                          | 15             | 5.7  | 26.7 | 12.9 |      |          |  |       |  |     |  |  |  |  |
| Nantucket              | 12                        | 14                       | 90                      | 30.09                                | 30.10                                  | +0.06                 | 29.6                     | -1.7                  | 55      | 8    | 37      | 4    | 25           | 22                   | 28                   | 27                                | 23                     | 80    | 5.19                  | +1.4                    | 13             | 11,957               | nw.              | 55        | ne.        | 23                 | 7           | 8                          | 16             | 6.4  | 7.0  | 5.0  |      |          |  |       |  |     |  |  |  |  |
| Block Island           | 26                        | 11                       | 46                      | 30.09                                | 30.12                                  | +0.05                 | 28.8                     | -2.2                  | 53      | 9    | 36      | 4    | 25           | 22                   | 27                   | 27                                | 24                     | 83    | 6.14                  | +2.4                    | 13             | 13,883               | nw.              | 57        | ne.        | 2                  | 10          | 5                          | 16             | 6.3  | 19.0 | 2.8  |      |          |  |       |  |     |  |  |  |  |
| Providence             | 190                       | 215                      | 251                     | 29.95                                | 30.13                                  | +0.07                 | 24.2                     | -3.0                  | 53      | 9    | 32      | -5   | 28           | 16                   | 29                   | 22                                | 14                     | 67    | 6.02                  | +2.3                    | 13             | 9,404                | nw.              | 49        | nw.        | 4                  | 13          | 6                          | 12             | 4.9  | 24.4 | 12.3 |      |          |  |       |  |     |  |  |  |  |
| Hartford               | 159                       | 70                       | 104                     | 30.15                                | 30.15                                  | +0.08                 | 23.8                     | -1.7                  | 55      | 9    | 31      | -7   | 28           | 16                   | 31                   | 17                                | 16                     | 66    | 5.01                  | +1.1                    | 13             | 6,729                | nw.              | 49        | nw.        | 4                  | 13          | 4                          | 14             | 20.3   | 9.0  |      |      |          |  |       |  |     |  |  |  |  |
| New Haven              | 106                       | 74                       | 153                     | 30.04                                | 30.17                                  | +0.09                 | 26.0                     | -2.2                  | 52      | 7    | 34      | -5   | 28           | 18                   | 29                   | 22                                | 15                     | 66    | 5.84                  | +1.9                    | 13             | 6,942                | n.               | 34        | nw.        | 14                 | 10          | 9                          | 12             | 5.8  | 20.9 | 7.1  |      |          |  |       |  |     |  |  |  |  |
| Middle Atlantic States |                           |                          |                         |                                      |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |           |            |                    |             |                            |                |  | 3.80 |      |      | +0.5     |  |       |  | 6.5 |  |  |  |  |
| Albany                 | 97                        | 107                      | 115                     | 30.07                                | 30.18                                  | +0.11                 | 19.6                     | -3.5                  | 50      | 9    | 28      | -12  | 28           | 11                   | 32                   | 18                                | 13                     | 74    | 4.10                  | +1.7                    | 15             | 6,348                | s.               | 23        | w.         | 1                  | 9           | 9                          | 13             | 5.9  | 20.8 | 5.0  |      |          |  |       |  |     |  |  |  |  |
| Binghamton             | 571                       | 60                       | 68                      | 29.15                                | 30.16                                  | +0.08                 | 22.2                     | -1.9                  | 54      | 10   | 31      | -13  | 28           | 14                   | 36                   | 23                                | 15                     | 80    | 2.73                  | +3                      | 17             | 5,314                | nw.              | 24        | sw.        | 3                  | 6           | 4                          | 21             | 7.5  | 13.0 | 2.0  |      |          |  |       |  |     |  |  |  |  |
| New York               | 314                       | 415                      | 454                     | 29.81                                | 30.17                                  | +0.07                 | 29.2                     | -1.7                  | 58      | 9    | 37      | 0    | 28           | 22                   | 29                   | 23                                | 15                     | 80    | 4.08                  | +4                      | 11             | 12,669               | nw.              | 63        | nw.        | 2                  | 10          | 7                          | 14             | 6.0  | 20.9 | 6.2  |      |          |  |       |  |     |  |  |  |  |
| Bellefonte             | 1,050                     | 8                        | 42                      | 29.02                                | 30.17                                  |                       | 24.2                     |                       | 50      | 10   | 32      | -1   | 24           | 16                   | 36                   | 22                                | 15                     | 80    | 2.03                  |                         | 13             |                      | w.               |           |            | 7                  | 8           | 19                         | 7.0            | 7.2  | 4    |      |      |          |  |       |  |     |  |  |  |  |
| Harrisburg             | 374                       | 94                       | 104                     | 29.77                                | 30.20                                  | +0.10                 | 28.2                     | -1.8                  | 54      | 10   | 35      | -1   | 28           | 22                   | 25                   | 23                                | 15                     | 80    | 1.95                  | -1.1                    | 11             | 6,050                | nw.              | 28        | nw.        | 14                 | 9           | 7                          | 15             | 6.3  | 15.1 | 2.2  |      |          |  |       |  |     |  |  |  |  |
| Philadelphia           | 114                       | 168                      | 367                     | 30.02                                | 30.19                                  | +0.08                 | 31.0                     | -1.6                  | 61      | 8    | 38      | 3    | 28           | 24                   | 25                   | 27                                | 20                     | 65    | 4.21                  | +9                      | 12             | 9,649                | n.               | 43        | nw.        | 14                 | 8           | 7                          | 16             | 6.0  | 21.5 | 7.7  |      |          |  |       |  |     |  |  |  |  |
| Reading                | 323                       | 283                      | 306                     | 29.83                                | 30.20                                  |                       | 28.4                     |                       | 50      | 10   | 35      | 9    | 36           | -2                   | 28                   | 21                                | 26                     | 25    | 19                    | 69                      | 3.05           | -5                   | 11               | 8,872     | nw.        | 51                 | nw.         | 14                         | 9              | 13   | 6.1  | 22.1 | 1.5  |          |  |       |  |     |  |  |  |  |
| Scranton               | 805                       | 72                       | 104                     | 29.28                                | 30.18                                  | +0.09                 | 24.8                     | -1.8                  | 54      | 9    | 32      | -7   | 28           | 17                   | 29                   | 23                                | 15                     | 78    | 3.05                  | -1.0                    | 15             | 5,778                | sw.              | 30        | sw.        | 3                  | 7           | 7                          | 16             | 6.8  | 18.1 | 6.4  |      |          |  |       |  |     |  |  |  |  |
| Atlantic City          | 52                        | 37                       | 172                     | 30.12                                | 30.18                                  | +0.07                 | 32.3                     | -2                    | 58      | 10   | 40      | -1   | 28           | 25                   | 29                   | 23                                | 15                     | 78    | 5.04                  | +1.6                    | 11             | 12,131               | nw.              | 43        | ne.        | 23                 | 8           | 7                          | 16             | 6.9  | 4.2  | 3.0  |      |          |  |       |  |     |  |  |  |  |
| Sandy Hook             | 22                        | 10                       | 57                      | 30.14                                | 30.16                                  |                       | 29.6                     |                       | 55      | 10   | 36      |      | 5            | 28                   | 23                   | 20                                | 27                     | 22    | 74                    | 3.53                    | -4             | 13                   | 11,675           | nw.       | 44         | nw.                | 14          | 13                         | 3              | 15   | 5.8  | 18.3 | 11.5 |          |  |       |  |     |  |  |  |  |
| Trenton                | 190                       | 88                       | 106                     | 29.97                                | 30.19                                  |                       | 29.0                     |                       | 58      | 10   | 37      |      | 2            | 28                   | 21                   | 29                                | 23                     | 20    | 71                    | 3.27                    | -0             | 13                   | 7,320            | n.        | 38         | nw.                | 14          | 10                         | 6              | 15   | 6.1  | 15.5 | 4.3  |          |  |       |  |     |  |  |  |  |
| Baltimore              | 123                       | 100                      | 215                     | 30.05                                | 30.19                                  | +0.07                 | 33.0                     | -1.5                  | 62      | 10   | 40      | -2   | 28           | 26                   | 29                   | 23                                | 15                     | 78    | 4.79                  | +1.3                    | 11             | 7,708                | sw.              | 40        | nw.        | 14                 | 11          | 5                          | 16             | 6.0  | 18.7 | 9.0  |      |          |  |       |  |     |  |  |  |  |
| Washington             | 112                       | 62                       | 85                      | 30.08                                | 30.21                                  | +0.08                 | 33.3                     | -1.5                  | 61      | 10   | 41      | -2   | 28           | 26                   | 29                   | 23                                | 15                     | 78    | 5.27                  | +1.7                    | 11             | 5,253                | nw.              | 32        | nw.        | 14                 | 10          | 5                          | 16             | 6.2  | 24.4 | 4.0  |      |          |  |       |  |     |  |  |  |  |
| Cape Henry             | 18                        | 8                        | 54                      | 30.16                                | 30.18                                  |                       | 39.4                     |                       | 65      | 11   | 46      | 16   | 27           | 33                   | 30                   | 36                                | 32                     | 78    | 2.64                  | -6                      | 8              | 10,853               | n.               | 49        | ne.        | 23                 | 3           | 9                          | 19             | 7.4  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Lynchburg              | 686                       | 5                        | 22                      | 29.44                                | 30.21                                  | +0.08                 | 36.2                     | -1.3                  | 65      | 11   | 46      | 16   | 27           | 33                   | 30                   | 36                                | 32                     | 78    | 2.64                  | -6                      | 8              | 10,853               | n.               | 49        | ne.        | 23                 | 3           | 9                          | 19             | 7.4  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Norfolk                | 91                        | 80                       | 125                     | 30.10                                | 30.20                                  | +0.07                 | 39.9                     | -1.7                  | 74      | 21   | 47      | 14   | 25           | 33                   | 26                   | 36                                | 32                     | 78    | 3.10                  | +1.8                    | 13             |                      | sw.              |           |            | 7                  | 17          | 7                          |                | 2.6  | 0    | 0    |      |          |  |       |  |     |  |  |  |  |
| Richmond               | 144                       | 11                       | 52                      | 30.06                                | 30.22                                  | +0.08                 | 36.1                     | -1.8                  | 73      | 21   | 45      | 1    | 28           | 27                   | 32                   | 31                                | 27                     | 76    | 4.41                  | +1.2                    | 9              | 6,326                | ne.              | 27        | n.         | 14                 | 7           | 17                         | 6.7            | 5.8  | 1.2  |      |      |          |  |       |  |     |  |  |  |  |
| Wytheville             | 2,304                     | 49                       | 55                      | 30.18                                | 30.18                                  | +0.04                 | 34.7                     | +1.7                  | 68      | 21   | 42      | 2    | 24           | 27                   | 32                   | 31                                | 27                     | 76    | 5.05                  | +2.0                    | 14             | 6,024                | w.               | 31        | nw.        | 1                  | 9           | 8                          | 14             | 1.4  | 1.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| South Atlantic States  |                           |                          |                         |                                      |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |           |            |                    |             |                            |                |  | 2.79 |      |      | -0.8     |  |       |  | 6.0 |  |  |  |  |
| Asheville              | 2,253                     | 89                       | 104                     | 27.77                                | 30.20                                  | +0.05                 | 40.2                     | +4.8                  | 66      | 21   | 49      | 10   | 24           | 31                   | 32                   | 35                                | 30                     | 72    | 4.68                  | +1.6                    | 12             | 7,380                | nw.              | 27        | e.         | 22                 | 6           | 10                         | 15             | 6.8  | 1.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Charlotte              | 779                       | 63                       | 86                      | 29.33                                | 30.19                                  | +0.04                 | 41.9                     | +7.7                  | 73      | 21   | 50      | 10   | 24           | 34                   | 32                   | 36                                | 30                     | 65    | 1.68                  | -2.3                    | 11             | 5,921                | ne.              | 20        | nw.        | 14                 | 7           | 9                          | 15             | 6.5  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Greensboro             | 886                       | 6                        | 56                      | 29.22                                | 30.20                                  |                       | 37.6                     |                       | 67      | 21   | 47      | 3    | 28           | 29                   | 28                   | 33                                | 29                     | 77    | 1.77                  |                         | 10             | 6,487                | ne.              | 28        | ne.        | 22                 | 6           | 7                          | 18             | 7.2  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Hatteras               | 11                        | 5                        | 50                      | 30.15                                | 30.16                                  | +0.02                 | 46.8                     | -3                    | 69      | 9    | 52      | 24   | 24           | 41                   | 18                   | 45                                | 43                     | 89    | 3.84                  | -6                      | 12             | 11,667               | n.               | 40        | nw.        | 23                 | 8           | 15                         | 6.4            | 4.0  | 0    |      |      |          |  |       |  |     |  |  |  |  |
| Raleigh                | 376                       | 103                      | 146                     | 29.77                                | 30.19                                  | +0.06                 | 41.0                     | -1                    | 73      | 21   | 50      | 8    | 28           | 32                   | 31                   | 37                                | 32                     | 76    | 2.40                  | -1.3                    | 10             | 6,869                | n.               | 28        | n.         | 23                 | 7           | 6                          | 18             | 6.9  | 2.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Wilmington             | 72                        | 73                       | 107                     | 30.10                                | 30.18                                  | +0.04                 | 47.6                     | +1.1                  | 72      | 22   | 56      | 15   | 28           | 39                   | 29                   | 43                                | 38                     | 76    | 2.89                  | -4                      | 11             | 7,167                | n.               | 32        | s.         | 21                 | 7           | 10                         | 14             | 6.4  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Charleston             | 48                        | 11                       | 92                      | 30.11                                | 30.16                                  | +0.01                 | 51.4                     | +1.5                  | 74      | 13   | 50      | 21   | 28           | 44                   | 24                   | 46                                | 41                     | 73    | 2.27                  | -8                      | 9              | 8,864                | ne.              | 30        | ne.        | 4                  | 10          | 9                          | 12             | 5.8  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Columbia, S. C.        | 351                       | 41                       | 57                      | 29.79                                | 30.18                                  | +0.03                 | 47.0                     | +1.0                  | 76      | 21   | 56      | 16   | 28           | 38                   | 32                   | 41                                | 35                     | 70    | 2.77                  | -2.0                    | 8              | 5,937                | ne.              | 24        | sw.        | 21                 | 11          | 6                          | 14             | 5.6  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Greenville, S. C.      | 1,039                     | 139                      | 139                     | 29.97                                | 30.16                                  |                       | 43.0                     |                       | 69      | 10   | 52      | 18   | 28           | 34                   | 30                   | 35                                | 30                     | 72    | 3.47                  | -1.4                    | 10             |                      | ne.              |           |            | 14                 | 6           | 11                         |                | 2.0  | 0    | 0    |      |          |  |       |  |     |  |  |  |  |
| Augusta                | 182                       | 62                       | 77                      | 29.97                                | 30.16                                  |                       | 48.4                     |                       | 78      | 21   | 58      | 20   | 28           | 39                   | 35                   | 42                                | 35                     | 65    | 2.94                  | -1.0                    | 8              | 4,902                | ne.              | 21        | s.         | 22                 | 11          | 6                          | 14             | 5.5  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Savannah               | 65                        | 73                       | 152                     | 30.08                                | 30.15                                  | +0.00                 | 53.8                     | +2.4                  | 79      | 17   | 63      | 26   | 28           | 44                   | 33                   | 46                                | 42                     | 74    | 2.98                  | +2                      | 10             | 8,556                | ne.              | 31        | w.         | 22                 | 13          | 8                          | 10             | 4.8  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Jacksonville           | 43                        | 86                       | 110                     | 30.09                                | 30.14                                  | +0.01                 | 57.2                     | +1.8                  | 81      | 17   | 66      | 31   | 24           | 48                   | 33                   | 50                                | 47                     | 79    | 2.77                  | -0                      | 7              | 6,630                | ne.              | 27        | sw.        | 22                 | 17          | 8                          | 6              | 3.9  | 4.0  | 0    |      |          |  |       |  |     |  |  |  |  |
| Florida Peninsula      |                           |                          |                         |                                      |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |           |            |                    |             |                            |                |  | 0.87 |      |      | -1.5     |  |       |  | 3.7 |  |  |  |  |
| Key West               | 22                        | 10                       | 64                      | 30.06                                | 30.08                                  | +0.02                 | 69.7                     | +2                    | 81      | 1    | 74      | 53   | 24           | 65                   | 16                   | 63                                | 61                     | 78    | 1.91                  | -0                      | 2              | 7,766                | n.               | 28        | nw.        | 23                 | 17          | 11                         | 3              | 3.4  | 0    | 0    |      |          |  |       |  |     |  |  |  |  |
| Miami                  | 25                        | 124                      | 168                     | 30.07</                              |  |                       |                          |                       |         |      |         |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |           |            |                    |             |                            |                |  |      |      |      |          |  |       |  |     |  |  |  |  |

TABLE 1.—Climatological data for Weather Bureau stations, January 1935—Continued

| District and station      | Elevation of instruments  |                          |                         | Pressure                             |  |                       | Temperature of the air |             |                       |         |      |              |         |      |              |                      | Precipitation        |                                   |                        | Wind  |                       |                        |                |                      | Clear days | Partly cloudy days | Cloudy days | average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |                  |           |      |
|---------------------------|---------------------------|--------------------------|-------------------------|--------------------------------------|--|-----------------------|------------------------|-------------|-----------------------|---------|------|--------------|---------|------|--------------|----------------------|----------------------|-----------------------------------|------------------------|-------|-----------------------|------------------------|----------------|----------------------|------------|--------------------|-------------|----------------------------|----------------|--|------------------|-----------|------|
|                           | Barometer above sea level | Thermometer above ground | Anemometer above ground | Station, reduced to mean of 24 hours | Sea level, reduced to mean of 24 hours | Departure from normal | Mean max. +            | Mean min. - | Departure from normal | Maximum | Date | Mean maximum | Minimum | Date | Mean minimum | Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Total | Departure from normal | Days with 0.01 or more | Total movement | Prevailing direction |            |                    |             |                            |                |  | Maximum velocity |           |      |
|                           |                           |                          |                         |                                      |  |                       |                        |             |                       |         |      |              |         |      |              |                      |                      |                                   |                        |       |                       |                        |                |                      |            |                    |             |                            |                |  | Miles per hour   | Direction | Date |
| Ohio Valley and Tennessee | Fl.                       | Fl.                      | Fl.                     | In.                                  | In.                                    | In.                   | °F.                    | °F.         | °F.                   | °F.     | °F.  | °F.          | °F.     | °F.  | °F.          | °F.                  | °F.                  | °F.                               | %                      | In.   | In.                   | Days                   | Miles          |                      |            |                    |             |                            |                |  |                  |           |      |
|                           |                           |                          |                         |                                      |  |                       | 36.4                   | +2.3        |                       |         |      |              |         |      |              |                      |                      |                                   | 75                     | 3.71  | -0.1                  |                        |                |                      |            |                    |             |                            |                | 0-10   | In.              | In.       |      |
| Chattanooga               | 762                       | 71                       | 214                     | 29.36                                | 30.19                                  | +0.03                 | 44.1                   | +2.9        | 67                    | 10      | 52   | 14           | 24      | 36   | 25           | 38                   | 32                   | 66                                | 2.54                   | -2.7  | 11                    | 6,201                  | ne.            | 28                   | se.        | 19                 | 9           | 8                          | 14             | 6.3  | 2.8              | 0.0       |      |
| Knoxville                 | 993                       | 66                       | 84                      | 29.10                                | 30.19                                  | +0.04                 | 41.4                   | +2.6        | 68                    | 7       | 49   | 10           | 24      | 34   | 31           | 37                   | 32                   | 74                                | 3.48                   | -1.2  | 12                    | 4,572                  | ne.            | 21                   | w.         | 17                 | 11          | 6                          | 14             | 5.7  | 7.1              | T         |      |
| Memphis                   | 399                       | 78                       | 86                      | 29.75                                | 30.19                                  | +0.03                 | 43.2                   | +2.3        | 71                    | 16      | 51   | 11           | 24      | 35   | 31           | 39                   | 36                   | 77                                | 8.74                   | +3.9  | 6                     | 6,363                  | n.             | 26                   | n.         | 17                 | 14          | 4                          | 13             | 5.4  | 3.2              | 0         |      |
| Nashville                 | 546                       | 168                      | 191                     | 29.62                                | 30.22                                  | +0.06                 | 40.6                   | +2.0        | 69                    | 21      | 49   | 7            | 24      | 32   | 57           | 39                   | 32                   | 75                                | 6.96                   | +2.2  | 10                    | 7,360                  | n.w.           | 32                   | s.         | 21                 | 4           | 12                         | 15             | 6.6  | 6.7              | T         |      |
| Lexington                 | 989                       | 5                        |                         |                                      |  |                       |                        |             |                       |         |      |              |         |      |              |                      |                      |                                   |                        |       |                       |                        |                |                      |            |                    |             |                            |                |  |                  |           |      |
| Louisville                | 525                       | 188                      | 234                     | 29.62                                | 30.23                                  | +0.09                 | 36.2                   | +1.8        | 62                    | 16      | 44   | 5            | 24      | 28   | 45           | 33                   | 28                   | 75                                | 3.37                   | -0.6  | 8                     | 8,290                  | s.             | 37                   | W.         | 21                 | 12          | 5                          | 14             | 6.1  | 2.1              | 0         |      |
| Evansville                | 431                       | 76                       | 116                     | 29.73                                | 30.21                                  | +0.07                 | 37.0                   | +3.5        | 65                    | 16      | 45   | 4            | 24      | 29   | 45           | 33                   | 28                   | 76                                | 3.35                   | -0.4  | 10                    | 7,397                  | s.             | 31                   | W.         | 17                 | 10          | 6                          | 15             | 5.9  | 1.4              | 0         |      |
| Indianapolis              | 822                       | 194                      | 230                     | 29.29                                | 30.20                                  | +0.08                 | 32.0                   | +3.6        | 62                    | 16      | 41   | 2            | 24      | 24   | 43           | 28                   | 23                   | 72                                | 2.33                   | -0.6  | 9                     | 8,998                  | s.             | 37                   | n.w.       | 17                 | 7           | 7                          | 17             | 6.6  | 1.1              | 0         |      |
| Terre Haute               | 575                       | 96                       | 129                     | 29.56                                | 30.20                                  | +0.08                 | 32.8                   | +3.1        | 63                    | 16      | 41   | 0            | 24      | 24   | 45           | 29                   | 25                   | 77                                | 2.51                   | -0.2  | 8                     | 7,573                  | s.             | 38                   | W.         | 16                 | 10          | 6                          | 15             | 6.1  | 3.0              | 0         |      |
| Cincinnati                | 627                       | 11                       | 51                      | 29.51                                | 30.22                                  | +0.10                 | 33.4                   | +3.1        | 60                    | 17      | 42   | 4            | 24      | 25   | 42           | 30                   | 26                   | 79                                | 2.86                   | -0.6  | 9                     | 6,566                  | s.             | 33                   | W.         | 17                 | 12          | 3                          | 16             | 6.2  | 7.9              | T         |      |
| Columbus                  | 822                       | 216                      | 230                     | 29.29                                | 30.20                                  | +0.09                 | 31.2                   | +2.6        | 59                    | 8       | 39   | 3            | 24      | 23   | 37           | 28                   | 24                   | 75                                | 1.50                   | -1.6  | 10                    | 9,231                  | se.            | 38                   | W.         | 17                 | 6           | 7                          | 18             | 6.8  | 2.6              | T         |      |
| Elkins                    | 1,947                     | 59                       | 78                      | 28.09                                | 30.24                                  | +0.12                 | 31.6                   | +1.2        | 69                    | 21      | 42   | -10          | 28      | 21   | 51           | 28                   | 24                   | 78                                | 5.42                   | +1.6  | 16                    | 5,745                  | w.             | 28                   | W.         | 17                 | 7           | 5                          | 19             | 6.9  | 6.6              | 1.3       |      |
| Parkersburg               | 637                       | 77                       | 84                      | 29.56                                | 30.24                                  | +0.12                 | 33.4                   | +0.9        | 68                    | 21      | 43   | -4           | 28      | 24   | 41           | 30                   | 26                   | 78                                | 2.71                   | -0.9  | 12                    | 5,519                  | se.            | 28                   | n.w.       | 14                 | 8           | 5                          | 18             | 6.3  | 0.8              | 2         |      |
| Pittsburgh                | 842                       | 353                      | 410                     | 29.26                                | 30.19                                  | +0.08                 | 32.1                   | +1.4        | 70                    | 21      | 40   | 4            | 24      | 24   | 41           | 29                   | 25                   | 74                                | 2.41                   | -0.6  | 13                    | 8,477                  | n.w.           | 38                   | sw.        | 21                 | 6           | 5                          | 20             | 7.4  | 5.6              | T         |      |
| Lower Lake region         |                           |                          |                         |                                      |  |                       | 23.7                   | -0.7        |                       |         |      |              |         |      |              |                      |                      |                                   | 77                     | 2.62  | 0.0                   |                        |                |                      |            |                    |             |                            | 7.6            |  |                  |           |      |
| Buffalo                   | 768                       | 243                      | 280                     | 29.28                                | 30.15                                  | +0.08                 | 23.8                   | -0.8        | 54                    | 7       | 31   | -3           | 24      | 17   | 27           | 22                   | 19                   | 81                                | 2.81                   | -0.5  | 22                    | 13,498                 | w.             | 61                   | sw.        | 17                 | 3           | 6                          | 22             | 7.9  | 12.0             | 2.5       |      |
| Canton                    | 448                       | 10                       | 61                      | 29.64                                | 30.15                                  | -----                 | 11.0                   | -5.3        | 49                    | 7       | 22   | -30          | 27      | 0    | 40           | 20                   | 16                   | 78                                | 3.24                   | +0.7  | 19                    | 7,184                  | sw.            | 30                   | W.         | 18                 | 8           | 8                          | 15             | 6.4  | 15.9             | 3.7       |      |
| Ithaca                    | 836                       | 77                       | 100                     | 29.21                                | 30.16                                  | -----                 | 22.1                   | -2.2        | 53                    | 7       | 31   | -11          | 28      | 14   | 36           | 20                   | 16                   | 78                                | 2.69                   | +0.5  | 16                    | 9,008                  | n.w.           | 32                   | se.        | 17                 | 3           | 3                          | 25             | 8.2  | 10.1             | 1.5       |      |
| Oswego                    | 335                       | 71                       | 85                      | 29.77                                | 30.16                                  | +0.09                 | 20.1                   | -3.8        | 51                    | 7       | 28   | -8           | 27      | 12   | 35           | 18                   | 14                   | 76                                | 2.75                   | -0.2  | 19                    | 9,654                  | s.             | 37                   | se.        | 17                 | 1           | 3                          | 27             | 8.8  | 20.0             | 4.2       |      |
| Rochester                 | 523                       | 86                       | 102                     | 29.56                                | 30.16                                  | +0.09                 | 23.2                   | -1.4        | 55                    | 7       | 30   | -2           | 28      | 16   | 33           | 21                   | 15                   | 70                                | 2.91                   | 0.0   | 23                    | 7,490                  | sw.            | 32                   | sw.        | 17                 | 2           | 7                          | 22             | 8.2  | 15.5             | 4.0       |      |
| Syracuse                  | 596                       | 65                       | 79                      | 29.49                                | 30.16                                  | +0.09                 | 21.5                   | -1.5        | 56                    | 7       | 30   | -14          | 27      | 13   | 36           | 20                   | 16                   | 78                                | 3.46                   | +0.4  | 20                    | 6,660                  | n.w.           | 27                   | se.        | 17                 | 3           | 10                         | 18             | 7.2  | 16.7             | 2.5       |      |
| Erie                      | 714                       | 130                      | 166                     | 29.36                                | 30.16                                  | +0.08                 | 27.1                   | +1.3        | 58                    | 21      | 34   | 1            | 27      | 20   | 31           | 24                   | 20                   | 75                                | 2.02                   | -0.8  | 18                    | 11,451                 | s.             | 49                   | sw.        | 17                 | 2           | 7                          | 22             | 7.6  | 4.5              | 4         |      |
| Cleveland                 | 762                       | 267                      | 337                     | 29.31                                | 30.16                                  | +0.07                 | 28.9                   | +2.4        | 58                    | 7       | 36   | 4            | 27      | 22   | 34           | 26                   | 22                   | 78                                | 2.15                   | -0.4  | 15                    | 11,595                 | s.             | 48                   | W.         | 3                  | 5           | 4                          | 22             | 7.9  | 4.2              | T         |      |
| Sandusky                  | 629                       | 5                        | 67                      | 29.46                                | 30.17                                  | +0.08                 | 28.1                   | +1.8        | 54                    | 7       | 35   | 5            | 24      | 21   | 31           | 24                   | 20                   | 75                                | 2.24                   | 0.0   | 12                    | 7,953                  | w.             | 32                   | sw.        | 17                 | 5           | 8                          | 18             | 7.4  | 5.0              | 0         |      |
| Toledo                    | 628                       | 79                       | 87                      | 29.48                                | 30.19                                  | +0.10                 | 26.7                   | +0.9        | 51                    | 7       | 34   | 2            | 24      | 20   | 28           | 24                   | 20                   | 77                                | 2.26                   | +0.1  | 10                    | 8,000                  | w.             | 34                   | W.         | 17                 | 8           | 5                          | 18             | 6.7  | 3.0              | 0         |      |
| Fort Wayne                | 857                       | 69                       | 84                      | 29.23                                | 30.19                                  | +0.09                 | 27.6                   | +0.7        | 53                    | 8       | 34   | 6            | 24      | 21   | 30           | 25                   | 22                   | 82                                | 2.58                   | +0.2  | 8                     | 7,517                  | s.             | 38                   | W.         | 17                 | 6           | 8                          | 17             | 6.9  | 3.0              | 0         |      |
| Detroit                   | 626                       | 5                        | 78                      | 29.46                                | 30.17                                  | +0.09                 | 24.8                   | +0.4        | 48                    | 7       | 31   | 0            | 27      | 18   | 26           | 23                   | 19                   | 80                                | 2.33                   | +0.3  | 14                    | 8,311                  | sw.            | 42                   | sw.        | 17                 | 4           | 8                          | 19             | 7.4  | 1.4              | 0         |      |
| Upper Lake region         |                           |                          |                         |                                      |  |                       | 17.6                   | -0.3        |                       |         |      |              |         |      |              |                      |                      |                                   | 83                     | 2.28  | +0.5                  |                        |                |                      |            |                    |             |                            | 7.6            |  |                  |           |      |
| Alpena                    | 609                       | 13                       | 89                      | 29.44                                | 30.15                                  | +0.11                 | 19.1                   | -0.2        | 41                    | 7       | 26   | -9           | 24      | 12   | 26           | 18                   | 14                   | 80                                | 2.05                   | +0.2  | 14                    | 9,432                  | n.w.           | 43                   | se.        | 17                 | 1           | 8                          | 22             | 8.2  | 19.5             | 7.0       |      |
| Escanaba                  | 612                       | 54                       | 60                      | 29.45                                | 30.15                                  | +0.10                 | 15.6                   | +0.2        | 36                    | 9       | 23   | -17          | 24      | 8    | 30           | 14                   | 11                   | 83                                | 2.10                   | +0.6  | 11                    | 7,803                  | n.w.           | 35                   | n.w.       | 3                  | 5           | 7                          | 19             | 6.9  | 21.9             | 16.0      |      |
| Grand Rapids              | 707                       | 70                       | 244                     | 29.36                                | 30.16                                  | +0.10                 | 24.8                   | +0.3        | 45                    | 6       | 31   | -1           | 27      | 19   | 27           | 23                   | 18                   | 77                                | 2.04                   | -0.3  | 10                    | 8,901                  | se.            | 43                   | sw.        | 17                 | 1           | 6                          | 24             | 8.8  | 7.3              | 8         |      |
| Lansing                   | 878                       | 6                        | 88                      | 29.18                                | 30.16                                  | -----                 | 22.4                   | -0.2        | 42                    | 7       | 29   | -2           | 27      | 16   | 28           | 22                   | 20                   | 91                                | 1.90                   | +0.1  | 13                    | 8,301                  | w.             | 35                   | W.         | 17                 | 4           | 6                          | 21             | 7.9  | 1.8              | 0         |      |
| Ludington                 | 637                       | 5                        | 54                      |                                      |  |                       |                        |             |                       |         |      |              |         |      |              |                      |                      |                                   |                        |       |                       |                        |                |                      |            |                    |             |                            |                |  |                  |           |      |
| Marquette                 | 734                       | 77                       | 111                     | 29.29                                | 30.13                                  | +0.09                 | 16.4                   | +1.1        | 38                    | 5       | 22   | -12          | 23      | 10   | 24           | 15                   | 13                   | 88                                | 2.52                   | +0.2  | 22                    | 7,901                  | w.             | 32                   | sw.        | 5                  | 2           | 6                          | 23             | 8.4  | 26.3             | 27.5      |      |
| Sault Sainte Marie        | 614                       | 11                       | 52                      | 29.41                                | 30.15                                  | +0.12                 | 11.6                   | -1.7        | 40                    | 5       | 23   | -25          | 23      | 3    | 32           | 12                   | 9                    | 87                                | 3.35                   | +1.4  | 20                    | 6,610                  | se.            | 38                   | n.w.       | 17                 | 4           | 5                          | 22             | 8.0  | 52.5             | 30.5      |      |
| Chicago                   | 673                       | 7                        | 131                     | 29.42                                | 30.18                                  | +0.08                 | 25.6                   | +1.9        | 44                    | 7       | 33   | -7           | 24      | 18   | 34           | 23                   | 19                   | 77                                | 2.34                   | +0.4  | 12                    | 8,371                  | n.w.           | 35                   | W.         | 17                 | 8           | 6                          | 17             | 6.8  | 6.0              | 7         |      |
| Green Bay                 | 617                       | 109                      | 141                     | 29.46                                | 30.16                                  | +0.10                 | 14.7                   | -1.0        | 38                    | 5       | 23   | -25          | 24      | 6    | 36           | 13                   | 10                   | 82                                | 1.44                   | -0.1  | 9                     | 8,330                  | sw.            | 37                   | n.w.       | 3                  | 7           | 9                          | 15             | 6.7  | 16.0             | 6.7       |      |
| Milwaukee                 | 681                       | 97                       | 221                     | 29.40                                | 30.17                                  | +0.09                 | 20.4                   | -0.2        | 44                    | 6       | 28   | -15          | 24      | 13   | 32           | 19                   | 15                   | 77                                | 2.50                   | +0.7  | 9                     | 10,690                 | n.w.           | 38                   | se.        | 12                 | 8           | 7                          | 16             | 6.8  | 10.2             | 1.6       |      |
| Duluth                    | 1,133                     | 5                        | 47                      | 28.86                                | 30.16                                  | +0.07                 | 5.2                    | -2.7        | 36                    | 5       | 14   | -38          | 23      | -4   | 37           | 4                    | 2                    | 87                                | 2.61                   | +1.6  | 10                    | 10,031                 | n.w.           | 41                   | n.w.       | 3                  | 7           | 4                          | 20             | 7.1  | 33.7             | 23.6      |      |
| North Dakota              |                           |                          |                         |                                      |  |                       | 3.0                    | -1.9        |                       |         |      |              |         |      |              |                      |                      |                                   | 86                     | 0.47  | 0.6                   |                        |                |                      |            |                    |             |                            | 7.1            |  |                  |           |      |
| Moorhead, Minn.           | 940                       | 50                       | 58                      | 29.14                                | 30.23                                  | +0.09                 | 1.5                    | -2.3        | 40                    | 5       | 11   | -31          | 23      | -8   | 41           | 1                    | 0                    | 94                                | 0.66                   | 0.0   | 11                    | 7,159                  | n.             | 28                   | n.         | 3                  | 3           | 5                          | 23             | 8.0  | 7.6              | 6.3       |      |
| Bismarck                  | 1,674                     | 8                        | 57                      | 28.30                                | 30.20                                  | +0.07                 | 8.6                    | +0.8        | 47                    | 31      | 19   | -32          | 23      | -2   | 49           | 6                    | 1                    | 72                                | 0.04                   | -0.4  | 3</                   |                        |                |                      |            |                    |             |                            |                |  |                  |           |      |

TABLE 1.—Climatological data for Weather Bureau stations, January 1935—Continued

| District and station       | Elevation of instruments  |                          |                         | Pressure                             |  |                       | Temperature of the air |                       |         |      |              |      |              |                      |                      |                                   | Precipitation          |       |                       | Wind                    |                |                      |                  | Clear days | Partly cloudy days | Cloudy days | average cloudiness, tenths | Total snowfall | Snow, sleet, and ice on ground at end of month |           |      |     |
|----------------------------|---------------------------|--------------------------|-------------------------|--------------------------------------|--|-----------------------|------------------------|-----------------------|---------|------|--------------|------|--------------|----------------------|----------------------|-----------------------------------|------------------------|-------|-----------------------|-------------------------|----------------|----------------------|------------------|------------|--------------------|-------------|----------------------------|----------------|--|-----------|------|-----|
|                            | Barometer above sea level | Thermometer above ground | Anemometer above ground | Station, reduced to mean of 24 hours | Sea level, reduced to mean of 24 hours | Departure from normal | Mean max. +2           | Departure from normal | Maximum | Date | Mean minimum | Date | Mean minimum | Greatest daily range | Mean wet thermometer | Mean temperature of the dew point | Mean relative humidity | Total | Departure from normal | Days with 0.01, or more | Total movement | Prevailing direction | Maximum velocity |            |                    |             |                            |                |  |           |      |     |
|                            |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      | Miles per hour   |            |                    |             |                            |                |  | Direction | Date |     |
|                            |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Northern Slope             |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Billings                   | 3,140                     | 4                        | 67                      | 27.39                                | 30.19                                  | +0.06                 | 8.3                    | -4.6                  | 49      | 24   | 19           | -34  | 20           | -2                   | 50                   | 7                                 | 5                      | 88    | -.81                  | +1                      | 12             | 6,353                | e.               | 35         | sw.                | 2           | 7                          | 5              | 19   | 7.1       | 12.4 | 0.4 |
| Havre                      | 2,505                     | 11                       | 67                      | 27.39                                | 30.19                                  | +0.06                 | 8.3                    | -4.6                  | 49      | 24   | 19           | -34  | 20           | -2                   | 50                   | 7                                 | 5                      | 88    | -.81                  | +1                      | 12             | 6,353                | e.               | 35         | sw.                | 2           | 7                          | 5              | 19   | 7.1       | 12.4 | 0.4 |
| Helena                     | 4,124                     | 85                       | 111                     | 25.76                                | 30.12                                  | -0.03                 | 20.0                   | -1.2                  | 56      | 25   | 30           | -29  | 31           | 11                   | 66                   | 17                                | 11                     | 69    | -.39                  | -.5                     | 9              | 4,306                | nw.              | 30         | s.                 | 4           | 3                          | 9              | 19   | 7.5       | 7.8  | T   |
| Kalispell                  | 2,973                     | 48                       | 56                      | 26.91                                | 30.08                                  | +0.04                 | 21.6                   | +1.2                  | 51      | 25   | 28           | -25  | 20           | 15                   | 26                   | 21                                | 19                     | 85    | 1.07                  | +.4                     | 1              | 94,330               | nw.              | 23         | n.                 | 17          | 1                          | 6              | 24   | 8.6       | 19.5 | T   |
| Miles City                 | 2,371                     | 48                       | 55                      | 27.51                                | 30.22                                  | +0.10                 | 13.4                   | -1.1                  | 48      | 31   | 25           | -26  | 20           | 2                    | 42                   | 11                                | 8                      | 81    | -.41                  | -.2                     | 11             | 4,155                | ne.              | 26         | n.                 | 2           | 8                          | 12             | 14   | 6.7       | 5.4  | 1.7 |
| Rapid City                 | 3,259                     | 50                       | 58                      | 26.61                                | 30.17                                  | +0.07                 | 25.5                   | +3.5                  | 63      | 30   | 40           | -20  | 20           | 11                   | 51                   | 19                                | 12                     | 65    | -.17                  | -.3                     | 6              | 5,509                | w.               | 36         | n.                 | 2           | 11                         | 9              | 11   | 8.5       | 1.9  | 0   |
| Cheyenne                   | 6,094                     | 50                       | 71                      | 23.96                                | 30.06                                  | +0.01                 | 33.3                   | +7.8                  | 62      | 27   | 45           | -23  | 20           | 21                   | 40                   | 25                                | 14                     | 48    | -.18                  | -.2                     | 3              | 9,045                | w.               | 33         | w.                 | 5           | 13                         | 11             | 7  | 4.4       | 2.0  | 0   |
| Lander                     | 5,372                     | 90                       | 68                      | 24.61                                | 30.12                                  | +0.00                 | 26.8                   | +8.5                  | 55      | 24   | 40           | -25  | 21           | 13                   | 41                   | 22                                | 17                     | 69    | -.05                  | -.5                     | 1              | 3,828                | sw.              | 33         | sw.                | 16          | 9                          | 15             | 7  | 5.1       | 9    | T   |
| Sheridan                   | 3,790                     | 10                       | 47                      | 26.07                                | 30.13                                  | +0.04                 | 22.4                   | +4.1                  | 45      | 30   | 34           | -20  | 14           | 25                   | 17                   | 10                                | 68                     | -.10  | -.8                   | 4                       | 3,369          | nw.                  | 21               | sw.        | 12                 | 12          | 8                          | 11             | 5.1  | 9         | 0    |     |
| Yellowstone Park           | 6,241                     | 11                       | 48                      | 26.07                                | 30.13                                  | +0.04                 | 22.4                   | +4.1                  | 45      | 30   | 34           | -20  | 14           | 25                   | 17                   | 10                                | 68                     | -.10  | -.8                   | 4                       | 3,369          | nw.                  | 21               | sw.        | 12                 | 12          | 8                          | 11             | 5.1  | 9         | 0    |     |
| North Platte               | 2,821                     | 11                       | 51                      | 27.11                                | 30.15                                  | +0.03                 | 29.2                   | +6.3                  | 66      | 8    | 43           | -19  | 21           | 15                   | 47                   | 22                                | 17                     | 71    | 1.00                  | -.2                     | 3              | 5,451                | w.               | 24         | nw.                | 16          | 9                          | 12             | 10   | 5.3       | 1.9  | 0   |
| Middle Slope               |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Denver                     | 5,292                     | 106                      | 113                     | 24.70                                | 30.04                                  | -0.01                 | 39.4                   | +9.6                  | 68      | 25   | 53           | -13  | 20           | 26                   | 55                   | 29                                | 12                     | 37    | 0.03                  | -0.4                    | 2              | 5,861                | s.               | 29         | w.                 | 22          | 12                         | 15             | 4  | 4.5       | 0.8  | 0.0 |
| Pueblo                     | 4,685                     | 80                       | 86                      | 25.29                                | 30.06                                  | +0.01                 | 38.4                   | +8.5                  | 71      | 26   | 55           | -13  | 21           | 22                   | 51                   | 28                                | 14                     | 43    | -.08                  | -.2                     | 2              | 5,701                | nw.              | 38         | nw.                | 5           | 19                         | 11             | 1  | 3.2       | 0.6  | 0.0 |
| Concordia                  | 1,392                     | 50                       | 58                      | 28.67                                | 30.20                                  | +0.06                 | 30.6                   | +4.2                  | 67      | 25   | 41           | -8   | 21           | 30                   | 40                   | 25                                | 21                     | 77    | -.07                  | -.5                     | 3              | 6,404                | n.               | 27         | nw.                | 16          | 13                         | 7              | 11   | 4.9       | 1    | 0.0 |
| Dodge City                 | 2,509                     | 10                       | 86                      | 27.47                                | 30.15                                  | +0.04                 | 36.0                   | +7.0                  | 69      | 25   | 49           | -8   | 21           | 23                   | 44                   | 29                                | 21                     | 64    | -.65                  | +.2                     | 3              | 8,734                | s.               | 38         | w.                 | 16          | 18                         | 5              | 8  | 4.1       | 4    | 0.0 |
| Wichita                    | 1,358                     | 85                       | 93                      | 28.68                                | 30.16                                  | +0.03                 | 35.7                   | +6.4                  | 69      | 16   | 46           | -7   | 21           | 26                   | 38                   | 31                                | 26                     | 72    | -.87                  | +.1                     | 3              | 8,451                | n.               | 34         | w.                 | 16          | 11                         | 8              | 12   | 5.4       | 1    | 0.0 |
| Oklahoma City              | 1,214                     | 10                       | 47                      | 28.84                                | 30.15                                  | +0.04                 | 42.4                   | +6.0                  | 75      | 16   | 53           | -2   | 21           | 32                   | 39                   | 36                                | 31                     | 72    | -.60                  | -.6                     | 3              | 7,959                | s.               | 31         | n.                 | 20          | 8                          | 11             | 12   | 6.2       | T    | 0.0 |
| Southern Slope             |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Abilene                    | 1,738                     | 10                       | 52                      | 28.29                                | 30.13                                  | +0.04                 | 49.8                   | +5.6                  | 80      | 9    | 62           | 7    | 21           | 38                   | 45                   | 41                                | 31                     | 58    | -.52                  | -.4                     | 4              | 6,869                | s.               | 30         | sw.                | 12          | 8                          | 6              | 17   | 6.6       | 0    | 0.0 |
| Amarillo                   | 3,676                     | 10                       | 49                      | 26.30                                | 30.08                                  | +0.02                 | 44.2                   | +8.9                  | 77      | 26   | 58           | -2   | 21           | 31                   | 47                   | 34                                | 24                     | 51    | -.75                  | +.2                     | 2              | 6,843                | sw.              | 29         | w.                 | 16          | 14                         | 8              | 9  | 4.5       | T    | 0.0 |
| Big Spring                 | 2,537                     | 5                        | 62                      | 27.47                                | 30.13                                  | +0.02                 | 48.4                   | +7.9                  | 79      | 9    | 62           | 6    | 21           | 35                   | 43                   | 38                                | 29                     | 56    | -.11                  | -.5                     | 3              | 6,404                | n.               | 27         | nw.                | 9           | 10                         | 12             | 5.5  | 0         | 0.0  |     |
| Del Rio                    | 944                       | 64                       | 71                      | 29.08                                | 30.05                                  | +0.02                 | 56.2                   | +3.9                  | 82      | 10   | 66           | 19   | 22           | 46                   | 36                   | 49                                | 42                     | 64    | -.36                  | -.2                     | 8              | 5,644                | se.              | 34         | nw.                | 21          | 11                         | 6              | 14   | 5.6       | 0    | 0.0 |
| Roswell                    | 3,566                     | 75                       | 85                      | 26.43                                | 30.09                                  | +0.05                 | 45.0                   | +5.8                  | 73      | 15   | 60           | 8    | 21           | 30                   | 43                   | 35                                | 22                     | 44    | -.06                  | -.5                     | 1              | 5,102                | s.               | 32         | sw.                | 19          | 14                         | 8              | 9  | 4.1       | T    | 0.0 |
| Southern Plateau           |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| El Paso                    | 3,778                     | 152                      | 175                     | 26.26                                | 30.10                                  | +0.09                 | 48.8                   | +3.8                  | 70      | 27   | 60           | 17   | 21           | 38                   | 34                   | 39                                | 27                     | 45    | -.24                  | -.2                     | 1              | 6,755                | nw.              | 45         | w.                 | 6           | 16                         | 8              | 7  | 3.6       | 0    | 0.0 |
| Albuquerque                | 4,972                     | 5                        | 39                      | 25.12                                | 30.14                                  | +0.04                 | 37.4                   | +1.3                  | 59      | 30   | 44           | 8    | 20           | 24                   | 32                   | 30                                | 25                     | 72    | 1.10                  | -.4                     | 8              | 4,259                | w.               | 27         | s.                 | 4           | 5                          | 10             | 7  | 5.3       | 10.1 | T   |
| Santa Fe                   | 7,013                     | 38                       | 53                      | 23.27                                | 30.14                                  | +0.10                 | 34.7                   | +5.9                  | 58      | 28   | 45           | -1   | 21           | 25                   | 32                   | 29                                | 24                     | 69    | 1.11                  | +.4                     | 7              | 4,816                | ne.              | 30         | sw.                | 19          | 13                         | 10             | 8  | 4.6       | 4.2  | 0   |
| Flagstaff                  | 6,907                     | 10                       | 59                      | 23.35                                | 30.09                                  | +0.04                 | 28.1                   | +1.4                  | 55      | 27   | 41           | -10  | 20           | 15                   | 42                   | 25                                | 18                     | 80    | 3.65                  | +.4                     | 11             | 5,282                | sw.              | 30         | sw.                | 19          | 12                         | 8              | 11   | 27.2      | T    | 0.0 |
| Phoenix                    | 1,068                     | 10                       | 57                      | 28.89                                | 30.06                                  | +0.03                 | 53.8                   | +2.6                  | 83      | 29   | 66           | 26   | 21           | 42                   | 40                   | 46                                | 37                     | 61    | -.95                  | +.2                     | 6              | 3,648                | e.               | 30         | w.                 | 19          | 10                         | 9              | 12   | 5.2       | 0    | 0.0 |
| Yuma                       | 141                       | 9                        | 54                      | 29.02                                | 30.07                                  | +0.02                 | 56.0                   | +1.6                  | 81      | 31   | 67           | 34   | 21           | 45                   | 34                   | 47                                | 36                     | 52    | -.74                  | +.3                     | 5              | 4,795                | n.               | 27         | w.                 | 19          | 15                         | 10             | 6  | 4.0       | 0    | 0.0 |
| Independence               | 3,957                     | 5                        | 26                      | 26.02                                | 30.12                                  | +0.05                 | 39.0                   | +8.9                  | 69      | 30   | 50           | 8    | 20           | 28                   | 33                   | 32                                | 36                     | 52    | -.83                  | -.1                     | 3              | 4,795                | s.               | 27         | w.                 | 15          | 8                          | 8              | 8  | 3.0       | 0    | 0.0 |
| Middle Plateau             |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Reno                       | 4,527                     | 61                       | 76                      | 25.47                                | 30.10                                  | -0.03                 | 33.8                   | +1.3                  | 59      | 30   | 44           | 8    | 20           | 24                   | 32                   | 30                                | 25                     | 72    | 1.10                  | -.4                     | 8              | 4,259                | w.               | 27         | s.                 | 4           | 5                          | 10             | 7  | 5.3       | 10.1 | T   |
| Winona                     | 6,090                     | 12                       | 20                      | 25.12                                | 30.14                                  | +0.04                 | 37.4                   | +1.3                  | 59      | 30   | 44           | 8    | 20           | 24                   | 32                   | 30                                | 25                     | 72    | 1.10                  | -.4                     | 8              | 4,259                | w.               | 27         | s.                 | 4           | 5                          | 10             | 7  | 5.3       | 10.1 | T   |
| Winnemucca                 | 4,344                     | 18                       | 56                      | 25.64                                | 30.12                                  | -0.04                 | 30.8                   | +2.2                  | 54      | 4    | 41           | -6   | 20           | 20                   | 33                   | 28                                | 24                     | 78    | 1.30                  | +.3                     | 10             | 6,478                | ne.              | 29         | sw.                | 17          | 8                          | 9              | 14   | 5.6       | 13.0 | T   |
| Modena                     | 5,473                     | 10                       | 46                      | 24.64                                | 30.10                                  | -0.00                 | 30.8                   | +4.1                  | 55      | 27   | 41           | -15  | 20           | 20                   | 42                   | 27                                | 24                     | 80    | -.94                  | +.1                     | 9              | 6,340                | sw.              | 28         | s.                 | 19          | 11                         | 5              | 15   | 5.3       | 4.1  | 0   |
| Salt Lake City             | 4,357                     | 86                       | 210                     | 25.68                                | 30.14                                  | -0.01                 | 33.8                   | +4.6                  | 53      | 10   | 42           | 2    | 21           | 26                   | 27                   | 30                                | 24                     | 68    | -.30                  | -1.0                    | 6              | 4,811                | s.               | 30         | w.                 | 19          | 14                         | 8              | 5.3  | 3.7       | 0    | 0.0 |
| Grand Junction             | 4,602                     | 60                       | 68                      | 25.47                                | 30.13                                  | +0.07                 | 34.0                   | +10.0                 | 59      | 31   | 44           | 5    | 21           | 24                   | 32                   | 28                                | 22                     | 66    | -.77                  | +.2                     | 4              | 4,008                | nw.              | 28         | s.                 | 19          | 12                         | 11             | 8  | 4.8       | 1.5  | 0   |
| Northern Plateau           |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| Baker                      | 3,471                     | 48                       | 53                      | 26.46                                | 30.13                                  | -0.03                 | 27.7                   | +2.8                  | 50      | 30   | 36           | -14  | 20           | 20                   | 23                   | 25                                | 21                     | 74    | 1.01                  | -.1                     | 9              | 5,392                | se.              | 22         | se.                | 22          | 3                          | 13             | 15   | 6.8       | 2.7  | 0   |
| Boise                      | 2,739                     | 79                       | 87                      | 27.24                                | 30.18                                  | -0.01                 | 31.0                   | +1.2                  | 53      | 4    | 38           | -6   | 20           | 24                   | 24                   | 28                                | 24                     | 77    | 1.76                  | -1.0                    | 10             | 3,908                | se.              | 19         | se.                | 4           | 1                          | 12             | 18   | 8.0       | 5.2  | 0   |
| Pocatello                  | 4,477                     | 60                       | 68                      | 25.51                                | 30.18                                  | -0.02                 | 26.8                   | +2.1                  | 48      | 5    | 37           | -17  | 21           | 17                   | 36                   | 23                                | 19                     | 75    | 1.37                  | 0                       | 11             | 6,066                | se.              | 32         | sw.                | 19          | 9                          | 7              | 15   | 6.3       | 15.4 | 1.5 |
| Spokane                    | 1,929                     | 101                      | 110                     | 27.94                                | 30.04                                  | -0.08                 | 31.3                   | +3.8                  | 57      | 24   | 37           | -18  | 20           | 25                   | 39                   | 28                                | 25                     | 79    | 2.06                  | -.1                     | 16             | 5,412                | s.               | 24         | s.                 | 21          | 5                          | 3              | 23   | 7.9       | 20.6 | 0   |
| Walla Walla                | 991                       | 57                       | 65                      | 28.94                                | 30.04                                  | -0.11                 | 36.4                   | +3.7                  | 69      | 24   | 43           | -4   | 20           | 30                   | 49                   | 33                                | 27                     | 73    | 1.18                  | -.8                     | 16             | 4,759                | s.               | 24         | s.                 | 21          | 1                          | 6              | 24   | 8.9       | 3.9  | 0   |
| Yakima                     | 1,076                     | 58                       | 67                      | 28.85                                | 30.03                                  | -0.03                 | 32.0                   | +4.6                  | 58      | 24   | 39           | -4   | 20           | 25                   | 48                   | 30                                | 26                     | 77    | 1.40                  | -.9                     | 8              | 3,114                | nw.              | 16         | se.                | 21          | 1                          | 6              | 24   | 8.6       | 4.6  | 0   |
| North Pacific Coast Region |                           |                          |                         |                                      |  |                       |                        |                       |         |      |              |      |              |                      |                      |                                   |                        |       |                       |                         |                |                      |                  |            |                    |             |                            |                |  |           |      |     |
| North Head                 | 211                       | 11                       | 56                      | 29.69                                | 29.92                                  | -0.13                 | 43.5                   | +1.4                  | 64      | 31   | 48           | 18   | 19           | 39                   | 29                   | 41                                | 38                     | 83    | 12.80                 | +3.7                    | 22             | 14,459               | s.               | 68         | s.                 | 21          | 4                          | 1              | 26   | 8.3       | 8.4  | 0   |
| Seattle                    | 125                       | 90                       | 321                     | 29.80                                | 29.93                                  | -0.12                 | 41.6                   | +2.1                  | 66      | 31   | 46           | 14   | 20           | 37                   | 21                   | 39                                | 35                     | 78    | 8.90                  | +4.0                    | 21             | 21,812               | se.              | 34         | s.                 | 16          | 1                          | 6              | 24   | 8.4       | 17.4 | 0   |
| Tatoosh Island             | 86                        | 10                       | 54                      | 29.76                                | 29.86                                  | -0.12                 | 42.3                   | +1.1                  | 64      | 31   | 45           | 18   | 19           | 39                   | 22                   | 40                                | 38                     | 84    | 22.67                 | +10.7                   | 26             | 15,821               | e.               | 59         | sw.                | 21          | 2                          | 2              | 27   | 8.0       | 7.2  | 0   |
| Medford                    | 1,329                     | 29                       | 58                      | 28.61                                | 30.06                                  | -0.06                 | 36.8                   | +2.8                  | 62      | 31   | 43           | 22   | 18           | 31                   | 31                   | 35                                | 33                     | 87    | 2.12                  | -.7                     | 15             | 3,367                | nw.              | 26         | se.                | 29          | 1                          | 2              | 28   | 9.3       | 1.8  | 0   |
| Portland, Oreg.            | 153                       | 68                       | 106                     | 29.82                                | 29.99                                  | -0.09                 | 40.4                   | +1.0                  | 65      | 24   | 46           | 12   | 20           | 35                   | 31                   | 38                                | 35                     | 78    | 3.45                  | -3.2                    | 18             | 5,474                | s.               | 27         | s.                 | 21          | 0                          | 5              | 26</   |           |      |     |

TABLE 2.—Data furnished by the Canadian Meteorological Service, January 1935

| Stations                            | Altitude<br>above<br>mean<br>sea level,<br>Jan. 1,<br>1919 | Pressure  |   |                                  | Temperature of the air            |                                  |                      |                      |         |        | Precipitation |                                  |                   |
|-------------------------------------|--|---|---|----------------------------------|-----------------------------------|----------------------------------|----------------------|----------------------|---------|--------|---------------|----------------------------------|-------------------|
|                                     |  | Station<br>reduced<br>to mean<br>of 24<br>hours | Sea level<br>reduced<br>to mean<br>of 24<br>hours | Depart-<br>ure<br>from<br>normal | Mean<br>max. +<br>mean<br>min. +2 | Depart-<br>ure<br>from<br>normal | Mean<br>maxi-<br>mum | Mean<br>mini-<br>mum | Highest | Lowest | Total         | Depart-<br>ure<br>from<br>normal | Total<br>snowfall |
|                                     | Feet   | In.   | In.   | In.                              | °F.                               | °F.                              | °F.                  | °F.                  | °F.     | °F.    | In.           | In.                              | In.               |
| Cape Race, Newfoundland             | 99   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Sydney, Cape Breton Island          | 48   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Halifax, Nova Scotia                | 88   | 29.74   | 29.85   | -0.12                            | 20.6                              | -1.2                             | 28.8                 | 12.5                 | 51      | -10    | 7.55          | +1.78                            | 22.0              |
| Yarmouth, Nova Scotia               | 65   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Charlottetown, Prince Edward Island | 38   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Chatham, New Brunswick              | 28   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Father Point, Quebec                | 20   | 30.05   | 30.08   | +1.10                            | 3.9                               | -4.1                             | 11.7                 | -3.9                 | 37      | -22    | 2.20          | -.65                             | 21.4              |
| Quebec, Quebec                      | 296  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Doucet, Quebec                      | 1,236  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Montreal, Quebec                    | 187  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Ottawa, Ontario                     | 236  | 29.89   | 30.18   | +1.15                            | 6.9                               | -2.7                             | 15.6                 | -1.8                 | 42      | -24    | 3.40          | +1.41                            | 23.3              |
| Kingston, Ontario                   | 285  | 29.82   | 30.16   | +1.11                            | 13.8                              | -3.3                             | 23.2                 | 4.5                  | 42      | -18    | 3.68          | +1.23                            | 13.7              |
| Toronto, Ontario                    | 379  | 29.74   | 30.17   | +1.12                            | 20.8                              | -6                               | 28.2                 | 13.3                 | 46      | -11    | 2.96          | +1.04                            | 11.3              |
| Cochrane, Ontario                   | 930  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| White River, Ontario                | 1,244  | 28.72   | 30.13   | +1.12                            | -5.7                              | -5.3                             | 9.7                  | -21.1                | 34      | -61    | 3.22          | +1.53                            | 32.2              |
| London, Ontario                     | 808  |   |   |                                  | 20.3                              |                                  | 27.2                 | 13.5                 | 40      | -19    | 4.20          |                                  | 21.2              |
| Southampton, Ontario                | 656  | 29.39   | 30.14   | +1.11                            | 17.8                              | -2.6                             | 25.4                 | 10.2                 | 42      | -16    | 3.45          | -.60                             | 28.7              |
| Parry Sound, Ontario                | 688  | 29.40   | 30.15   | +1.14                            | 10.0                              | -3.8                             | 19.4                 | .7                   | 40      | -33    | 3.93          | -.15                             | 36.5              |
| Port Arthur, Ontario                | 644  | 29.42   | 30.19   | +1.12                            | 2.7                               | -4                               | 11.5                 | -6.0                 | 37      | -35    | 2.07          | +1.25                            | 20.7              |
| Winnipeg, Manitoba                  | 760  | 29.33   | 30.24   | +1.13                            | -7.6                              | -8                               | 1.6                  | -16.9                | 28      | -43    | 1.61          | +1.73                            | 16.1              |
| Minnedosa, Manitoba                 | 1,090  | 28.27   | 30.24   | +1.14                            | -7.2                              | .0                               | 2.3                  | -16.7                | 40      | -40    | 1.84          | +1.04                            | 18.4              |
| Le Pas, Manitoba                    | 860  |   | 30.27   |                                  | -14.8                             |                                  | -7.4                 | -22.2                | 36      | -46    | .58           |                                  | 5.8               |
| Qu'Appelle, Saskatchewan            | 2,115  | 27.70   | 30.11   | +1.03                            | -4.5                              | -7                               | 4.1                  | -13.1                | 45      | -42    | 1.92          | +1.42                            | 19.2              |
| Moose Jaw, Saskatchewan             | 1,759  |   |   |                                  | -1.1                              |                                  | 9.0                  | -11.2                | 45      | -40    | 1.48          |                                  | 14.8              |
| Swift Current, Saskatchewan         | 2,392  | 27.43   | 30.12   | +1.03                            | 2.0                               | -1.1                             | 12.8                 | -8.8                 | 42      | -40    | 1.65          | +1.01                            | 16.4              |
| Medicine Hat, Alberta               | 2,365  | 27.45   | 30.06   | -.01                             | 4.4                               | -1.1                             | 15.2                 | -6.3                 | 43      | -38    | 2.10          | +1.53                            | 21.0              |
| Calgary, Alberta                    | 3,540  | 26.21   | 30.09   | +1.06                            | 7.3                               | -1.1                             | 19.4                 | -4.8                 | 52      | -38    | 1.19          | +1.66                            | 11.9              |
| Banff, Alberta                      | 4,521  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Prince Albert, Saskatchewan         | 1,450  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Battleford, Saskatchewan            | 1,592  | 28.35   | 30.22   | +1.14                            | -12.8                             | -6.9                             | -2.8                 | -22.9                | 28      | -55    | .85           | +1.45                            | 8.5               |
| Edmonton, Alberta                   | 2,150  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Kamloops, British Columbia          | 1,262  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Victoria, British Columbia          | 230  | 29.62   | 29.88   | -.09                             | 38.7                              | +2                               | 42.5                 | 35.0                 | 56      | 10     | 13.28         | +7.89                            | 10.0              |
| Barkerville, British Columbia       | 4,180  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Estevan Point, British Columbia     | 20   |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Prince Rupert, British Columbia     | 170  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |
| Hamilton, Bermuda                   | 151  |   |   |                                  |                                   |                                  |                      |                      |         |        |               |                                  |                   |

## LATE REPORTS FOR DECEMBER 1934

|                                     |       |       |       |       |      |      |      |      |    |     |       |       |      |
|-------------------------------------|-------|-------|-------|-------|------|------|------|------|----|-----|-------|-------|------|
| Cape Race, Newfoundland             | 99    |       |       |       | 28.2 |      | 33.7 | 22.6 | 48 | 7   | 4.27  |       | 22.6 |
| Sydney, Cape Breton Island          | 48    | 29.69 | 29.74 | -0.15 | 25.8 | -2.4 | 31.3 | 20.3 | 54 | 12  | 4.14  | -0.49 | 24.0 |
| Halifax, Nova Scotia                | 88    | 29.59 | 29.70 | -.26  | 23.3 | -4.3 | 28.8 | 17.8 | 57 | 4   | 6.08  | +1.96 | 11.6 |
| Yarmouth, Nova Scotia               | 65    | 29.79 | 29.86 | -.12  | 28.1 | -2.6 | 33.4 | 22.8 | 59 | 12  | 5.64  | +1.87 | 25.4 |
| Charlottetown, Prince Edward Island | 38    | 29.73 | 29.77 | -.17  | 19.1 | -5.2 | 25.4 | 12.8 | 56 | -1  | 4.49  | +1.83 | 37.6 |
| Chatham, New Brunswick              | 28    | 29.74 | 29.78 | -.16  | 12.0 | -5.0 | 21.6 | 2.4  | 44 | -15 | 2.21  | -1.01 | 17.3 |
| Father Point, Quebec                | 20    | 29.88 | 29.91 | -.04  | 12.2 | -3.2 | 18.0 | 6.5  | 46 | -8  | 2.35  | -.48  | 19.1 |
| Quebec, Quebec                      | 296   | 29.66 | 30.00 | -.01  | 11.8 | -3.4 | 18.0 | 5.7  | 44 | -12 | 3.24  | -.45  | 23.9 |
| Kingston, Ontario                   | 285   | 29.72 | 30.06 | +1.02 | 20.1 | -3.6 | 27.5 | 12.7 | 52 | -10 | 2.35  | -.89  | 9.3  |
| Moose Jaw, Saskatchewan             | 1,759 |       |       |       | 12.0 |      | 20.5 | 3.6  | 48 | -31 | .45   |       | 4.5  |
| Calgary, Alberta                    | 3,540 | 26.26 | 30.08 | +1.14 | 19.5 | +1.3 | 27.8 | 11.2 | 58 | -28 | .26   | -.33  | 2.6  |
| Edmonton, Alberta                   | 2,150 | 27.70 | 30.12 | +1.12 | 9.2  | -3.9 | 16.9 | 1.5  | 42 | -35 | .82   | +1.08 | 7.7  |
| Kamloops, British Columbia          | 1,262 | 28.86 | 30.20 | +1.16 | 26.4 | -2.5 | 30.3 | 22.4 | 42 | -6  | 1.06  | +1.28 | 8.0  |
| Estevan Point, British Columbia     | 20    |       |       |       | 42.5 |      | 47.4 | 37.5 | 54 | 30  | 18.01 |       | 27.8 |
| Prince Rupert, British Columbia     | 170   |       |       |       | 36.1 |      | 41.1 | 31.1 | 60 | 12  | 7.81  |       | 1.4  |
| Hamilton, Bermuda                   | 151   | 29.93 | 30.10 | -.02  | 64.6 | -.1  | 69.2 | 60.0 | 78 | 50  | 5.62  | +1.13 | .0   |

## SEVERE LOCAL STORMS, JANUARY 1935

(Compiled by Mary O. Souder)

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

| Place                  | Date  | Time                                  | Width of<br>path<br>(yards) | Loss<br>of<br>life | Value of<br>property<br>destroyed | Character of storm            | Remarks  | Authority                          |
|------------------------|-------|---------------------------------------|-----------------------------|--------------------|-----------------------------------|-------------------------------|--|------------------------------------|
| Beadle County, S. Dak. | 2-3   | 9:15 p. m.,<br>2d to a.<br>m., of 3d. |                             | 2                  |                                   | Wind, dust, and<br>cold wave. | High northwest wind, accompanied by severe local<br>dust storm and rapidly falling temperature,<br>caused the death of 2 boys, 6 and 11 years of age,<br>when they lost their way enroute home from a<br>neighboring farm about one-half mile distant,<br>on open prairie 10 miles northeast of Huron. | Official, U. S. Weather<br>Bureau. |
| Stamps, Ark.           | 7     |                                       |                             |                    |                                   | Wind.                         | 3 persons injured; considerable damage to roofs of<br>buildings.   | Do.                                |
| Alpena, Mich.          | 12-13 |                                       |                             |                    |                                   | Snow.                         | 9 inches of snow fell in 24 hours; rural roads<br>blocked for several days.  | Do.                                |
| Baltimore, Md.         | 14    |                                       |                             |                    |                                   | Gale.                         | Old shed 70 by 900 feet and an unoccupied lumber<br>shed demolished; house damaged by an up-<br>rooted tree and a number of homes slightly<br>damaged.   | Do.                                |

## SEVERE LOCAL STORMS, JANUARY 1935—Continued

| Place  | Date  | Time                                     | Width of path (yards) | Loss of life | Value of property destroyed | Character of storm          | Remarks   | Authority |
|--|-------|--|-----------------------|--------------|-----------------------------|-----------------------------|---|-----------|
| Grand Rapids, Mich.                                | 16    | P. m.                                    |                       |              |                             | Sleet                       | Sleet froze to windshields of automobiles; several motor accidents reported; traffic delayed; in many cases bus and truck schedules were canceled.  | Do.       |
| Lancaster, Wis.                                    | 16    |  |                       |              | \$7,000                     | Glaze                       | Main damage to wires.   | Do.       |
| Southern and central Michigan.                     | 16-17 |  |                       |              |                             | Sleet and glaze             | Highway transportation greatly interrupted; numerous accidents reported.  | Do.       |
| Buffalo and western New York.                      | 17    |  |                       | 1            |                             | Wind and glaze              | Freezing rain at Buffalo from 1:15 to 6:15 a. m., and average hourly wind velocity of over 50 miles from 9 a. m., to 3 p. m.; several persons injured; no air traffic from the Buffalo Airport; Grand Island Ferry unable to run due to an ice jam; considerable damage to telephone lines in outlying districts. This storm was general, severe weather conditions being felt throughout the Buffalo area and western New York.  | Do.       |
| Northern Delta counties, Miss.                     | 17-23 |  |                       | 29           | 4,500,000                   | Excessive rain and flood.   | Loss estimated includes expenditures for relief and property damage.  | Do.       |
| Louann, near, Ark.                                 | 19    |  |                       |              | 1,500                       | Wind                        | Several oil derricks blown down and small buildings damaged.  | Do.       |
| Oklahoma City, Okla., and vicinity.                | 19-20 | P. m.                                    |                       |              | 1,000                       | Glaze                       | Damage to electric wires and poles.   | Do.       |
| St. Louis, Mo.                                     | 20    | do.                                      |                       |              |                             | Sleet                       | An inch of sleet, unmelted, fell during the night and remained on the ground in measurable depths for about a week; traffic interrupted.  | Do.       |
| Freeport, Ill.                                     | 20    |  |                       |              | 500                         | do.                         | Scattered damage to trees, shrubbery, and wires.  | Do.       |
| Pontotoc County, Miss., northeastern portion.      | 20    | P. m.                                    |                       |              |                             | Wind                        | Farm buildings and tenant house damaged.  | Do.       |
| Galveston, Tex.                                    | 20-21 | do.                                      |                       |              | 125,000                     | Heavy rain, sleet and snow. | These conditions, preceded by low temperature, caused the loss of 1,500 cattle for which there was no shelter; water pipes and automobile radiators frozen; many fish in the waters of this vicinity stunned or killed by the freeze.   | Do.       |
| Southwestern Counties, Tenn.                       | 20-21 |  |                       | 2            | 400,000                     | Rain and flood              | Many towns isolated; practically all highway traffic into Memphis and a number of other cities in the area halted on the 21st due to washed-out roads and bridges and inundated highways; railroads in some instances were caused to detour traffic hundreds of miles; air traffic inconvenienced by flooded airports; many homes flooded over a wide area; large number of livestock died; thousands of dollars' of feed lost when barns were destroyed; steamboats and other river craft torn from their moorings on Wolf River; in the vicinity of Memphis alone the damage will exceed \$300,000 plus an additional \$100,000 for the repairs of State Highway bridges; 2 persons drowned at Jackson. | Do.       |
| Eastern Shore, Md.                                 | 22-23 |  |                       |              |                             | Glaze                       | Much damage to wires and trees.   | Do.       |
| Pennsylvania, eastern portion.                     | 22-23 |  |                       |              |                             | Snow and wind               | One of the heaviest snowstorms in this section in recent years; main highways closed for 2 days or more because of drifts and some secondary roads not opened to traffic for a week or more; trains delayed.  | Do.       |
| Atlantic City, N. J., and vicinity.                | 22-24 | 12:30 a. m., of 22d—6:40 a. m., of 24th. |                       |              |                             | Rain, sleet and snow.       | This was one of severest sleet storms in this vicinity; in Northfield, N. J., the street railway service was practically suspended for 4 days.  | Do.       |
| Sandy Hook, N. J.                                  | 22-24 |  |                       |              |                             | Snow                        | Most severe snowstorm of record at this station; northeast gales caused drifting of from 2-6 feet and all roads on Sandy Hook blocked; no traffic on or off the Hook on the 24th; mail delayed and schools suspended for several days.  | Do.       |
| Jacksonville, Fla.                                 | 23    | 7:56-9:05 a. m.                          |                       |              |                             | do.                         | Heaviest snowfall since 1899.   | Do.       |
| Between 5-fathom Lightship and Fenwick Island, Va. | 23    | P. m.                                    | 300                   | 13           | 120,000                     | Wind                        | 3 barges from Norfolk to New York, caught in high wind and unable to weather the storm, were lost.  | Do.       |
| Lower Hudson Valley and Long Island, N. Y.         | 23    |  |                       | 4            |                             | Heavy snow                  | Heavy drifts blocked highways causing much delay to automobile and bus traffic; 4 deaths reported in New York.  | Do.       |
| Richmond, Va.                                      | 23    |  |                       |              |                             | Glaze                       | Considerable damage to wires, trees and highways; sidewalks slippery.   | Do.       |
| Nantucket, Mass.                                   | 23-24 | 9:45 a. m., of 23d—2 a. m. of 24th.      |                       |              |                             | Sleet                       | Unusually heavy sleet storm, 10.9 inches being recorded; all woodwork coated with half an inch of ice; no damage to wires.  | Do.       |
| Maryland, northern portion                         | 23-24 |  |                       |              |                             | Snow and wind               | Depth of accumulated snow from the 15th to 23d from 10 to 18 inches; strong winds caused drifts several feet high blocking roads and stalling traffic.  | Do.       |
| Havre, Mont.                                       | 24    |  |                       |              | 2,000                       | Wind                        | A strong chinook wind rapidly melted the snow cover east of the Divide and in Hill County caused the flooding of Bull Hook Creek; streets and basements flooded; damage estimated for Havre alone.  | Do.       |
| James River, Va., vicinity of.                     | 24-25 |  |                       |              | 110,000                     | Rain and flood              | Flood waters in the James River damaged property and prospective crops to the extent of \$10,000; freezing and thawing damaged State highways to the extent of approximately \$100,000.   | Do.       |

1 Miles instead of yards.

Chart I. Departure (°F.) of the Mean Temperature from the Normal

| Month | Year | Departure (°F.) | Year | Departure (°F.) | Year | Departure (°F.) | Year | Departure (°F.) |
|-------|------|-----------------|------|-----------------|------|-----------------|------|-----------------|
| Jan   | 1900 | 0.5             | 1901 | 0.2             | 1902 | 0.8             | 1903 | 0.1             |
| Feb   | 1900 | 0.3             | 1901 | 0.1             | 1902 | 0.6             | 1903 | 0.0             |
| Mar   | 1900 | 0.4             | 1901 | 0.2             | 1902 | 0.7             | 1903 | 0.1             |
| Apr   | 1900 | 0.6             | 1901 | 0.3             | 1902 | 0.9             | 1903 | 0.2             |
| May   | 1900 | 0.8             | 1901 | 0.4             | 1902 | 1.1             | 1903 | 0.3             |
| Jun   | 1900 | 1.0             | 1901 | 0.5             | 1902 | 1.3             | 1903 | 0.4             |
| Jul   | 1900 | 1.2             | 1901 | 0.6             | 1902 | 1.5             | 1903 | 0.5             |
| Aug   | 1900 | 1.1             | 1901 | 0.5             | 1902 | 1.4             | 1903 | 0.4             |
| Sep   | 1900 | 0.9             | 1901 | 0.4             | 1902 | 1.2             | 1903 | 0.3             |
| Oct   | 1900 | 0.7             | 1901 | 0.3             | 1902 | 1.0             | 1903 | 0.2             |
| Nov   | 1900 | 0.5             | 1901 | 0.2             | 1902 | 0.8             | 1903 | 0.1             |
| Dec   | 1900 | 0.4             | 1901 | 0.1             | 1902 | 0.7             | 1903 | 0.0             |
| Jan   | 1904 | 0.6             | 1905 | 0.3             | 1906 | 0.9             | 1907 | 0.2             |
| Feb   | 1904 | 0.4             | 1905 | 0.2             | 1906 | 0.7             | 1907 | 0.1             |
| Mar   | 1904 | 0.5             | 1905 | 0.3             | 1906 | 0.8             | 1907 | 0.2             |
| Apr   | 1904 | 0.7             | 1905 | 0.4             | 1906 | 1.0             | 1907 | 0.3             |
| May   | 1904 | 0.9             | 1905 | 0.5             | 1906 | 1.2             | 1907 | 0.4             |
| Jun   | 1904 | 1.1             | 1905 | 0.6             | 1906 | 1.4             | 1907 | 0.5             |
| Jul   | 1904 | 1.3             | 1905 | 0.7             | 1906 | 1.6             | 1907 | 0.6             |
| Aug   | 1904 | 1.2             | 1905 | 0.6             | 1906 | 1.5             | 1907 | 0.5             |
| Sep   | 1904 | 1.0             | 1905 | 0.5             | 1906 | 1.3             | 1907 | 0.4             |
| Oct   | 1904 | 0.8             | 1905 | 0.4             | 1906 | 1.1             | 1907 | 0.3             |
| Nov   | 1904 | 0.6             | 1905 | 0.3             | 1906 | 0.9             | 1907 | 0.2             |
| Dec   | 1904 | 0.5             | 1905 | 0.2             | 1906 | 0.8             | 1907 | 0.1             |

Chart I. Departure (°F.) of the Mean Temperature from the Normal, January 1935

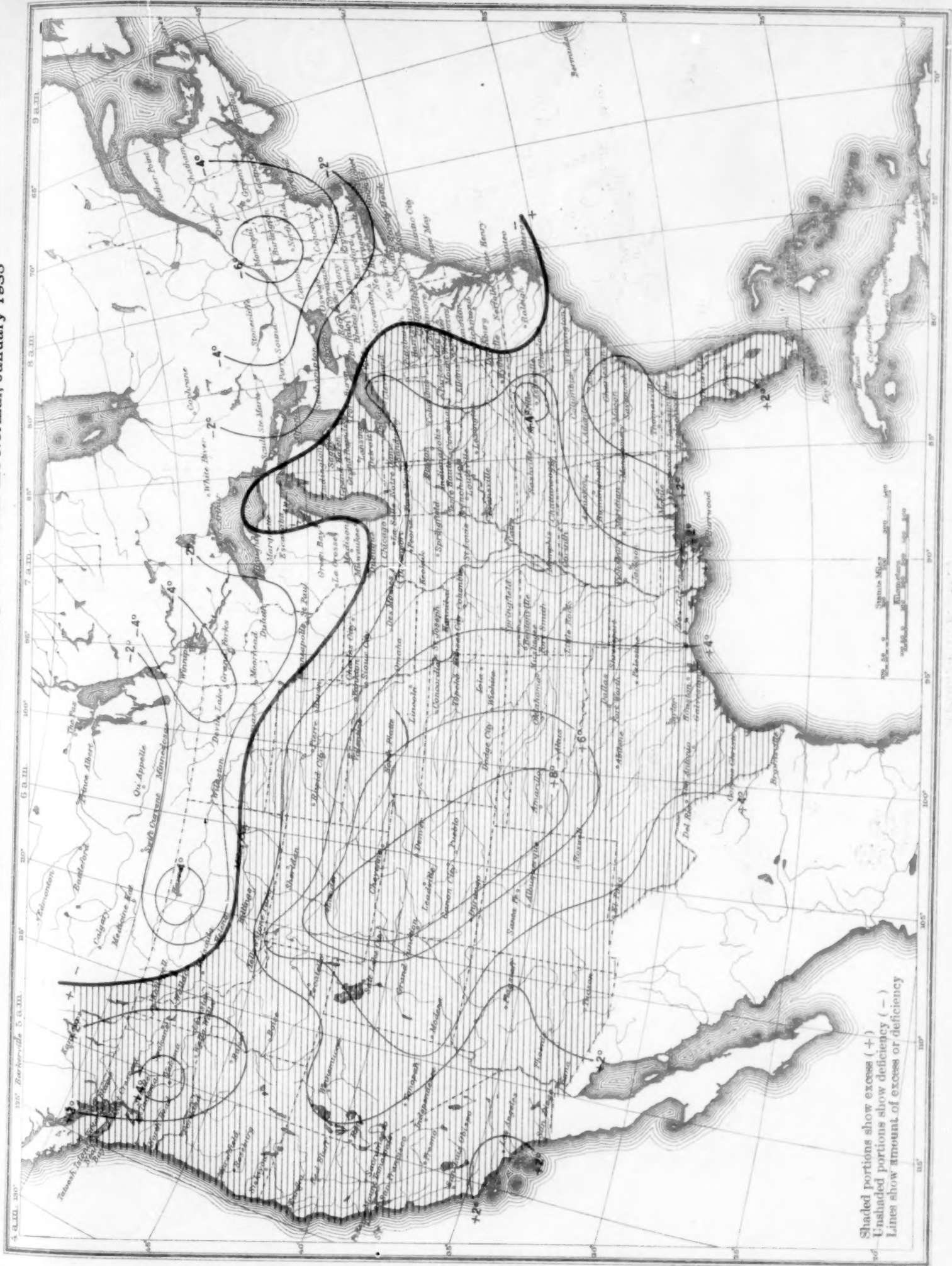
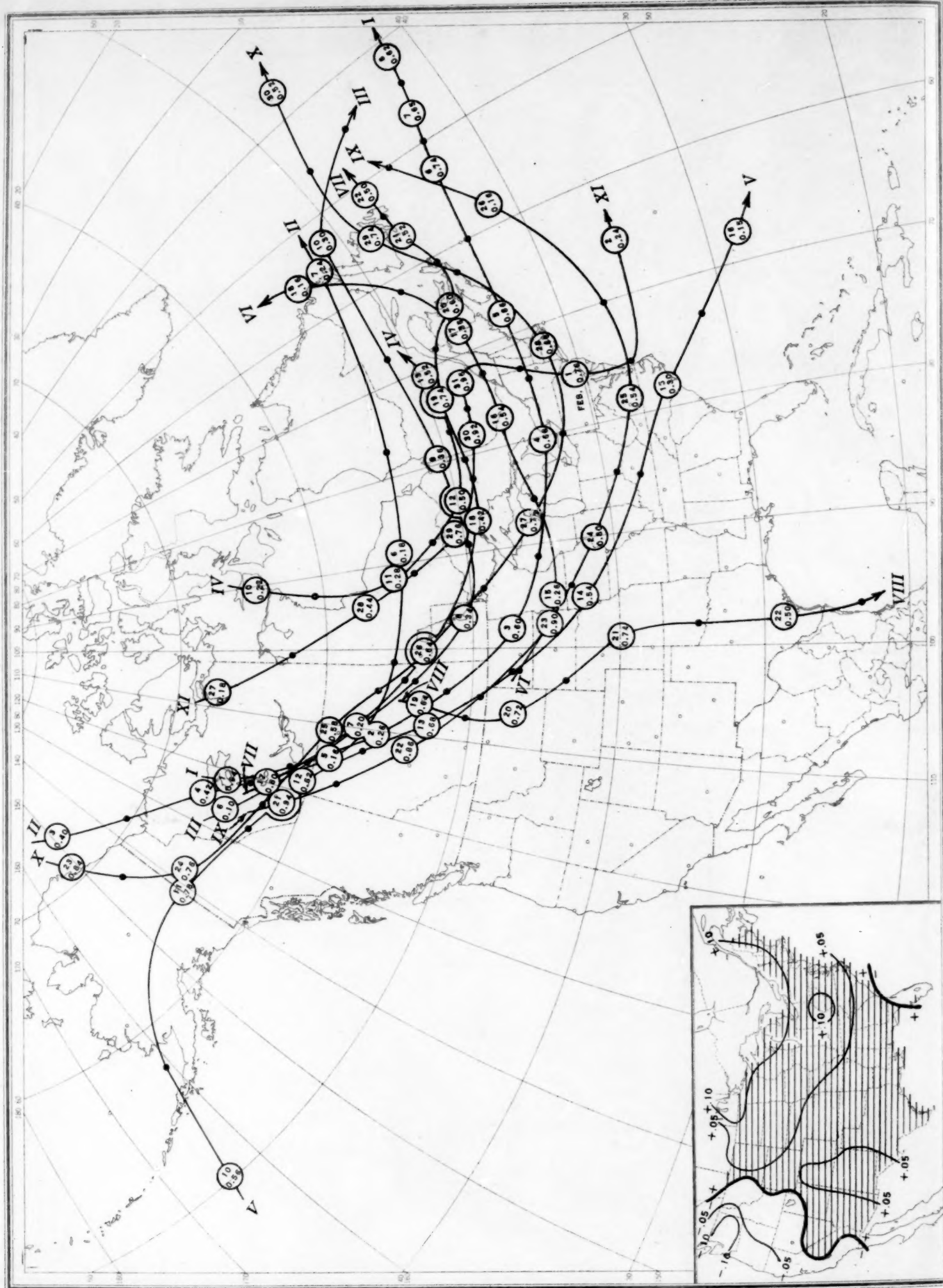


Chart II. Tracks of Centers of Anticyclones, January 1935. (Inset) Departure of Monthly Mean Pressure from Normal  
(Plotted by G. E. Dunn)

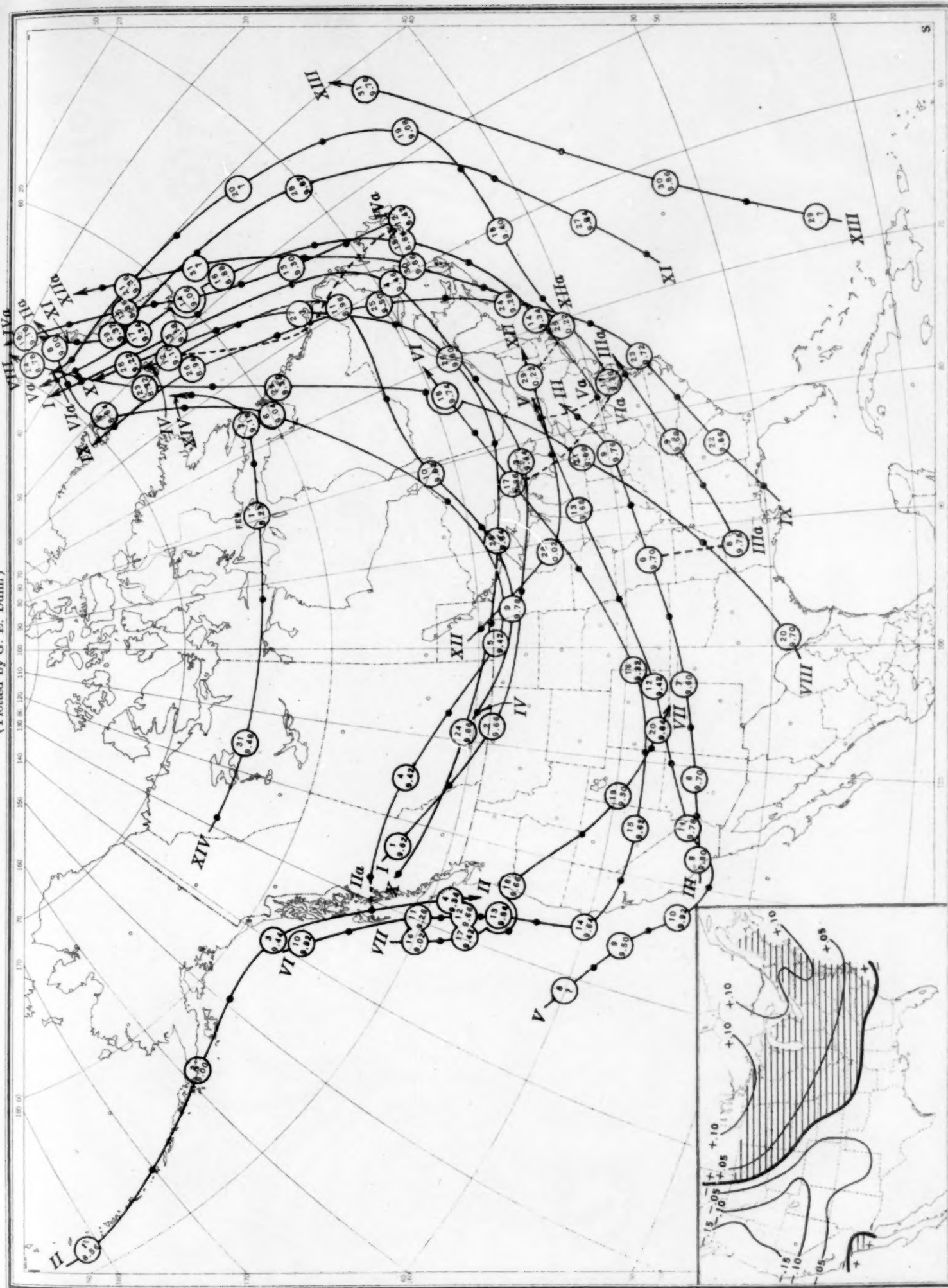


Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, January 1935. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, January 1935. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, January 1935

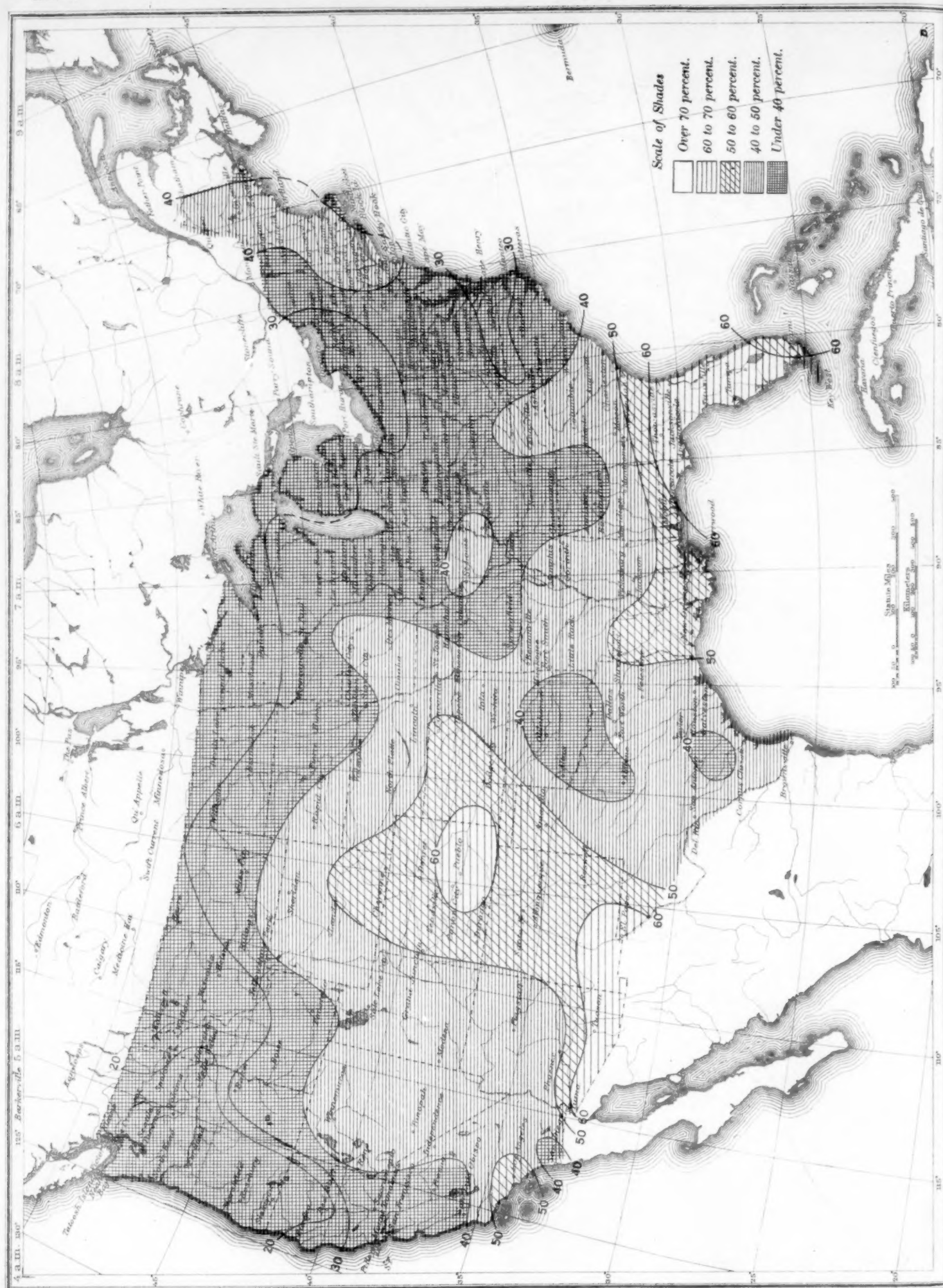


Chart V. Total Precipitation, Inches, January 1935. (Inset) Departure of Precipitation from Normal

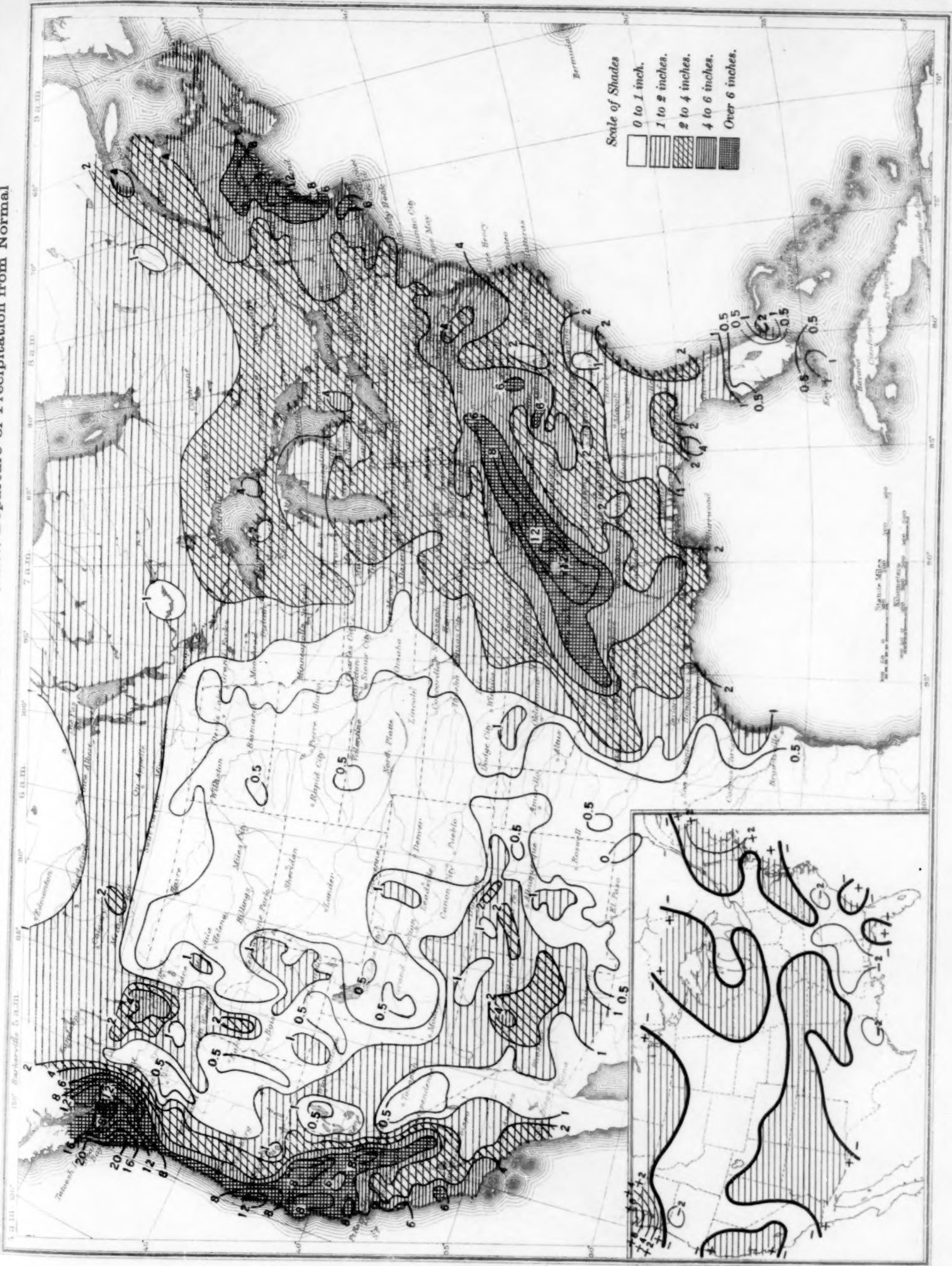


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, January 1935

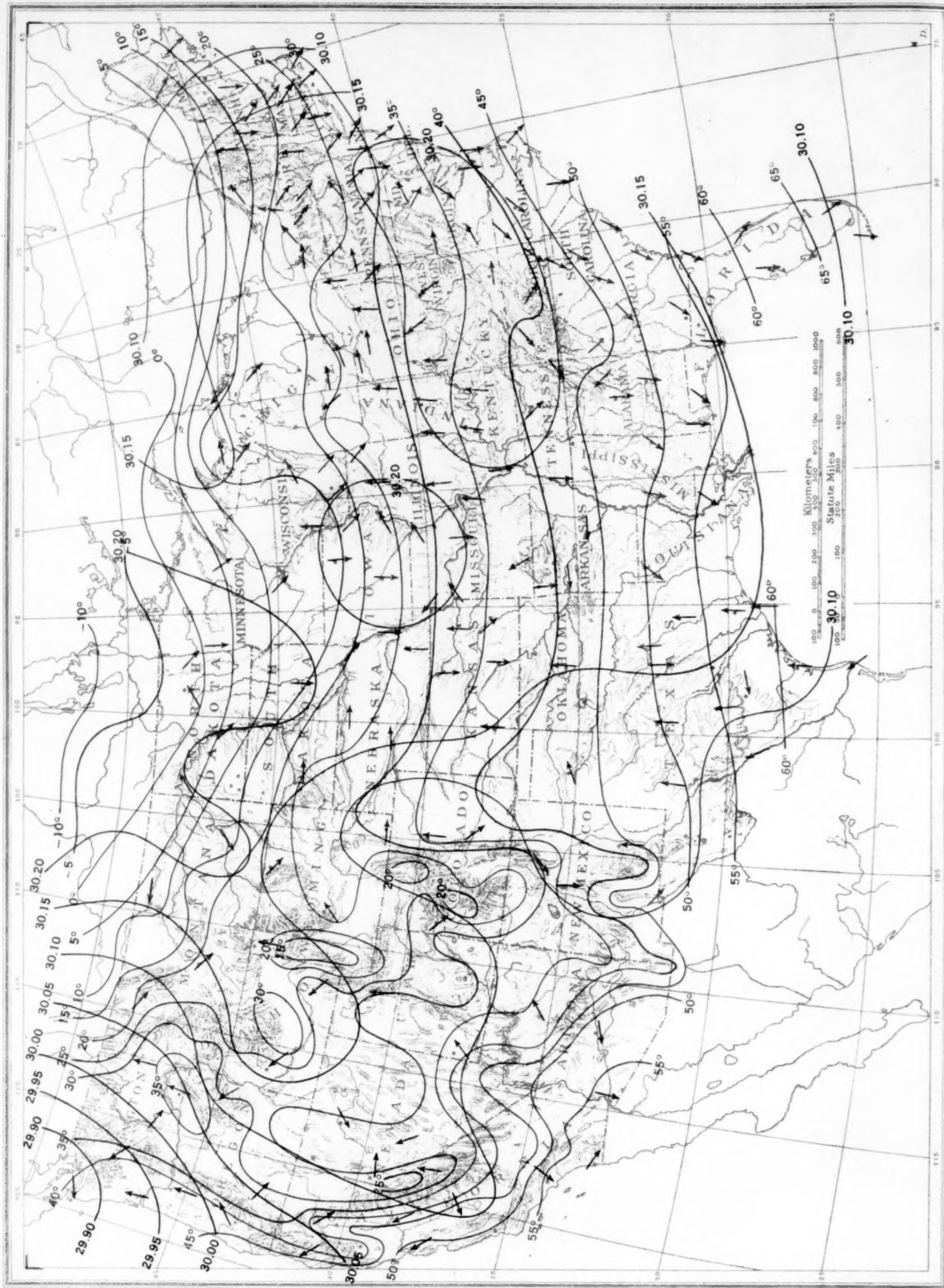


Chart VII. Wind Roses for Selected Stations

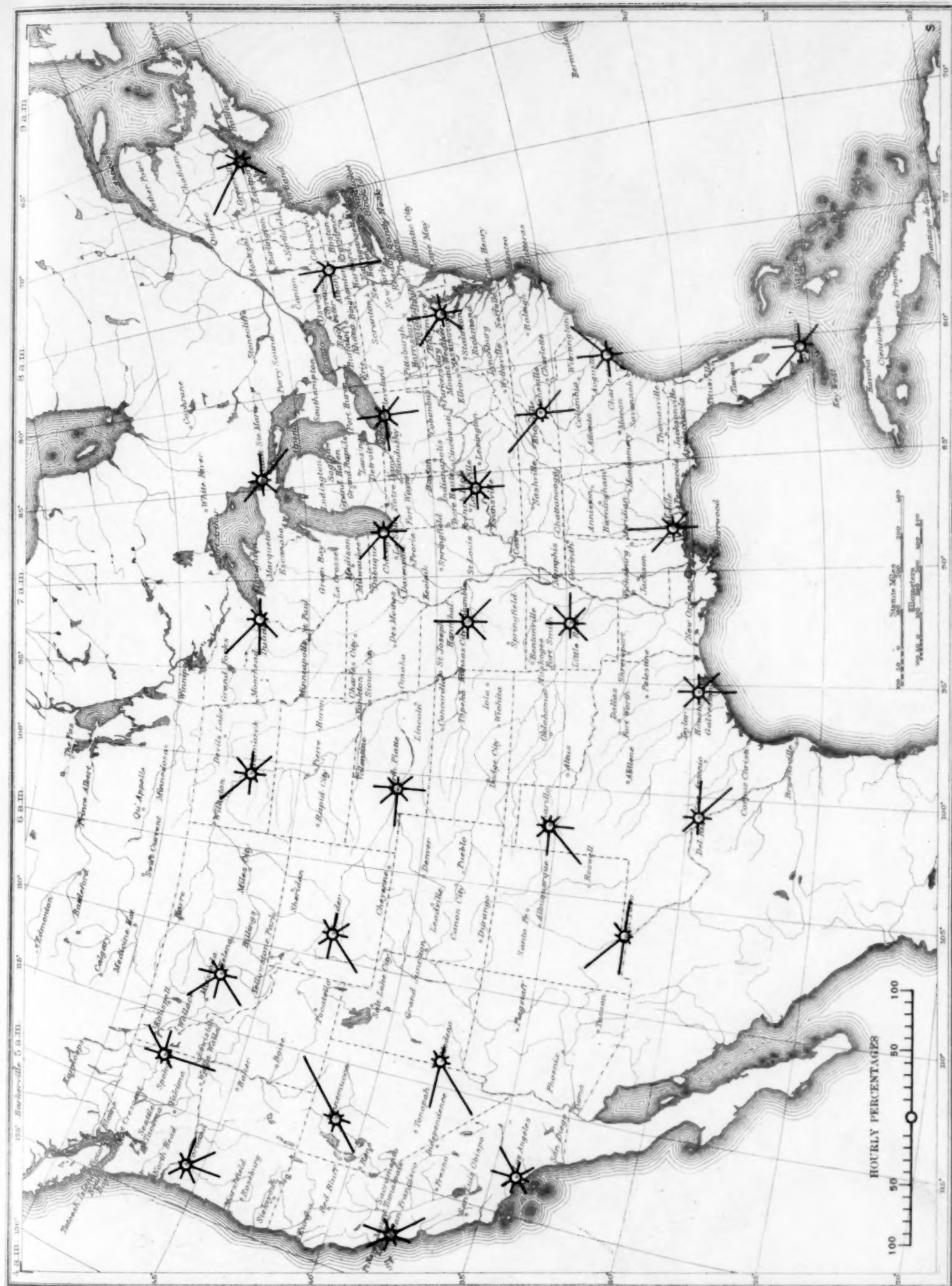


Chart VIII. Total Snowfall, Inches, January 1935. (Inset) Depth of Snow on Ground at 8 p. m., Monday, January 28, 1935

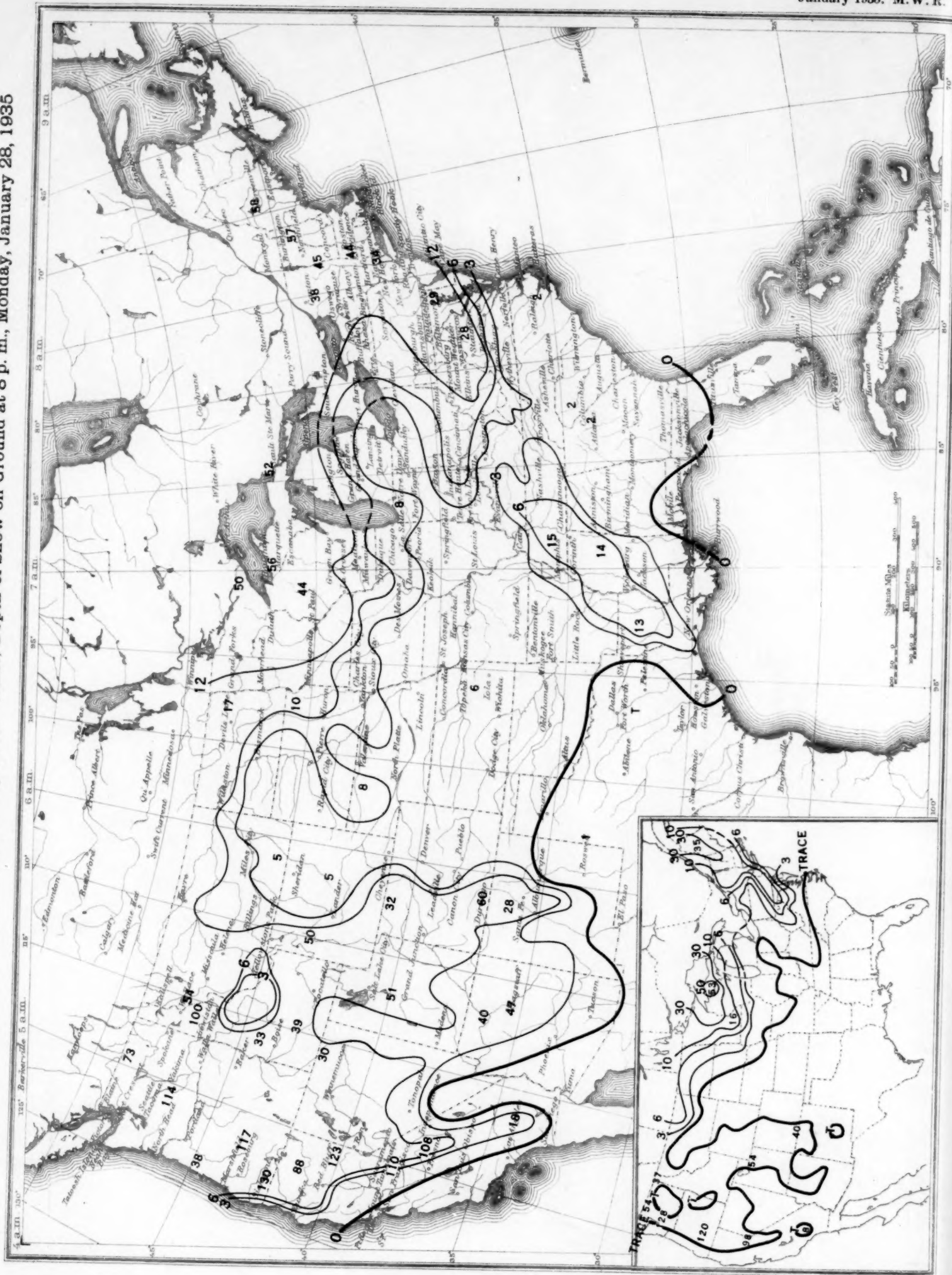


Chart IX. Weather Map of North Atlantic Ocean, January 2, 1935  
(Plotted from the Weather Bureau Northern Hemisphere Chart)

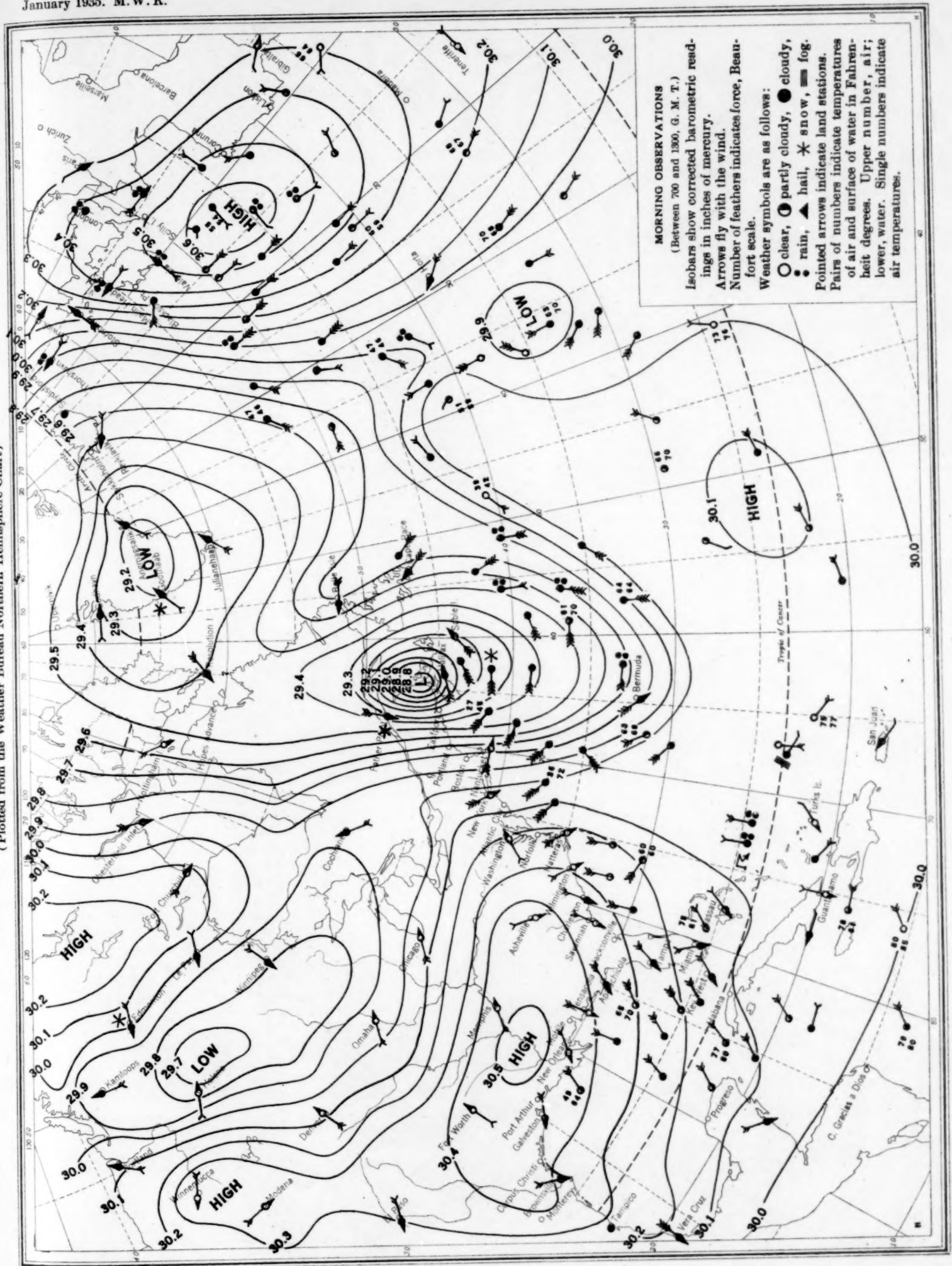


Chart X. Weather Map of North Atlantic Ocean, January 15, 1935  
(Plotted from the Weather Bureau Northern Hemisphere Chart)

